

SCIENCE REPORTER

SEPTEMBER 1964
RUPEE ONE



POSITIONING OF SATELLITES



COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH
(Publications and Information Directorate, New Delhi)

MEDICAL ENTRANCE RESULTS 1983



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1st in PMT
in PMT (Punjab)



Shakti Srivastava
1st in BHU
in BHU Varanasi



Paulose George T
1st in Kerala
1st Medical Ent



Raman Sood
1st in Medical
1st Ent Himachal



Sanjiv Sharma
1st in LMC
1st Ludhiana



Anil Kumar Power
1st in BHU (Varanasi)
1st amongst S C / S T



Sanjiv Sharma
1st in Pre Med
1st Panjab Univ



Pankaj Vohra
2nd in BHU
2nd Varanasi



Sanjiv Sharma
2nd in PMT
2nd Panjab



Shakti Srivastava
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2nd Pondicherry



Mandeep Mahra
2nd in MGIMS
2nd Wardha



Amol Nanak Singh
1st in Pre Medical
1st G. N. D. University



Chetan P. Shah
3rd in MGIMS
3rd Wardha



Savita Suri
3rd amongst girls
3rd in PMT (PB)



Subhesh Prashed
3rd in Medical
3rd Entrance Bihar



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3rd in PMT
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SCIENCE REPORTER

SEPTEMBER 1984
VOL. 21 No. 9



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Publications Information Division, New Delhi

Cover : APPLE spacecraft in geostationary orbit (Transparency: Courtesy-Author)

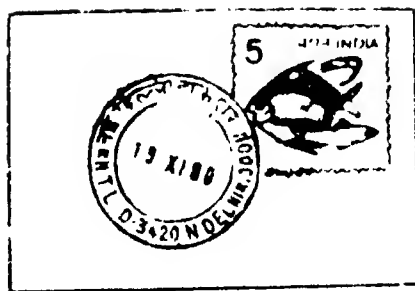
Science Reporter is published monthly. Publications and Information Directorate (CSIR) assumes no responsibility for statements and opinions advanced by contributors and the editorial staff.

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(Strange Animals)



LETTERS

Adulteration of oils

Sir, This refers to Adulteration of edible oils by N G Wagle (S.R., April 1984). The author has wrongly stated that *Argemone mexicana* weed infests mustard fields. He has also stated that seeds of *Argemone mexicana* may get mixed with mustard seeds more by accident than by design. We wish to emphasise that *Argemone mexicana* is not indigenous to India but has been introduced from Mexico. The weed, commonly known as 'Prickly poppy', never grows along with mustard plants, nor does it form part of the latter. *Argemone* grows in wastelands. Unscrupulous traders, however, collect *Argemone* seeds and deliberately mix them with the seeds of various varieties of mustard like *Brassica campestris* var. *brown toria*.

The problem of the two seeds looking alike has been solved scientifically in our laboratory by using optical microscope, stereo binocular and scanning electron microscope.

VIJAYA GUPTA

J. P. GOYAL

I. C. LAMBA

Department of Botany

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Antimicrobial properties of milk

Sir, The article 'Germicidal properties of milk' (S.R., March 1984) by V. K. Batish, J. S. Yadav and H. Chander was informative. I would like to add some more information to it.

The normal human milk also contains an antiprotazoal substance, besides antibacterial factors, which is lacking in cow or goat milk. Frances Gillin and David Reiner of University of California Medical Centre and Chi-Sun Wang of the Oklahoma Medical Research Foundation (Science, Vol. 221, p. 1290) have isolated a novel antibiotic like substance (seems to be an enzyme) from normal human milk. They named this substance as bile salt stimulated lipase (BSL). The cultures of *Giardia lamblia* (a major cause of gut disease, prevalent among children), *Entamoeba histolytica* (dysentery amoeba) and *Trichomonas vaginalis* (causing diseases in urogenital tract) was exposed to various concentrations of normal human milk for various lengths of time. Three per cent milk killed half the parasites within 30 minutes and even 0.3% milk killed them. This antiprotazoal property of human milk is not related to antibodies though its mode of action is still unknown.

G. S. BISHI

P. O. Virbhadra

Rishikesh-249202

Fibonacci numbers

Sir, The article on Fibonacci numbers published in S.R., Feb 1984 was interesting.

Property 11 can be generalised as each n^{th} term of Fibonacci series is divisible by F_n , i.e.

each 2nd term is divisible by 1 (= F_2)

each 3rd term is divisible by 2 (= F_3),

each 4th term is divisible by 3 (= F_4)

each 5th term is divisible by 5 (= F_5)

each 6th term is divisible by 8 (= F_6)

each 7th term is divisible by 13 (= F_7)

each 15th term is divisible by 610

(= F_{15})

each n^{th} term is divisible by F_n

SATLENDI SARKAR

35 Bhagabati Chatterjee

Street, Calcutta 700056

Bird migration

Sir, Bird migration by Vishnu Kant Pathak and Atanu Kumar Pati (S.R., Feb. 1984) was interesting and informative. Different species of migratory birds, different kinds of migrations, stimulus for migration, ecological significance, etc. were dealt with in detail. However I wish to add the following.

Altitude migration is notable amongst 'Pheasant birds'. In the spring, these birds flock up to occupy higher zones and move back to foothills (Himalayas) and plains in winter. These migrants are at the verge of extinction due to brutal hunting by local people.

T. J. Roberts had observed the migratory red necked phalaropes (*Phalaropus lobatus*) in Pakistan. These migrants spend the winter at Sirandah lake so close to the open sea. Surkhab valley also attracts a number of breeding migrants in summer.

Accipiter gularis seen in Andaman and Nicobar Islands is a strong migrator, taking off in winter in some numbers to as far south as Sumatra and Jawa. It does not go far east. It has been described as a scarce summer-visitor in Korea by Gore and Won (1971). There are breeding records in Japan also.

Reference

Journal of the Bombay Natural History Society, Vol. 77 (1) & Vol. 77 (3).

SP. V. TAMILMANI

Research Assistant

126, R.K. Mutt Road

Madras-600 028

Birds in colours

Sir, Birds in colours by Vinod Kumar (S.R., March 1984) was interesting. Factors responsible for colouration in feathers of birds were quite informative. However mention may be made of the 'Indrian

(Continued on page 440)

ON POSITIONING OF SATELLITES

A. V. PATKI

Spacecraft orbital manoeuvre and attitude control are a part of the sophisticated practice of space technology. Their understanding would unravel the mysteries of the Universe

FOUR hundred years ago, man believed that the earth was at the centre of Universe and that other bodies revolved around it. With the Copernican model, this belief was shattered and the science of astronomy was revolutionised. Stars and planets were differentiated. The planetary motions were studied in detail and the famous Kepler's laws were discovered. After a few more years, Newton and his gravitation theory gave the analytical base and quantum boost to man's understanding of the Universe.

Today, movements of 'heavenly' bodies can be explained by very simple laws of physics. The same laws that govern the movement of these celestial objects also control flights of man-made spacecraft and artificial satellites.

The study of flight-path of these objects is divided into two phases: controlled flight paths and uncontrolled flight paths. The first phase corresponds to the powered flights of rockets and spacecraft and is known as astrodynamics while the second phase concerns the natural motion of these bodies in the absence of propulsion, called coasting phase, and covers most aspects of celestial mechanics. This study, in addition to the simple laws of motion (also established by Newton), forms the famous 'Newton's law of gravitational attraction'. This, in its basic form, states that two bodies attract

each other with a force proportional to the product of their masses and is inversely proportional to the distance between them, viz.,

$$F = \frac{G m_1 m_2}{r^2}$$

These laws determine the spacecraft motion, in essence. Though simple in its basic form, the study becomes highly mathematical, partly because of other bodies involved and partly because of other effects. However, the high speed digital computers and the proper engineering judgement make the motion predictable to sufficient accuracy needed for a particular mission. The motion of a spacecraft is further split into a combination of a translatory motion and rotational movement. In spacecraft terminology, the first refers to 'orbital mechanics' and the second to the 'attitude dynamics'. Though these motions are often coupled, theory and also practice allow separate treatments of these aspects.

Let us restrict our attention to the practical orbits of man-made satellites. If we neglect the effects of far-off bodies, we get a situation known as a two-body problem. Further, mass of the spacecraft being much smaller than the other heavenly objects, we get what is known as central force motion. This central force motion results in orbits of the form of the conic sections with the focus at the centre of attraction. There are various parameters and their combinations

which can describe an orbit completely, the simplest being the position vector at a particular time, say at launcher burn-out condition. Depending upon the total energy (potential + kinetic) the spacecraft enters either elliptic, parabolic or hyperbolic orbit (Fig. 1). The latter two types of orbits are nonrespective types and are used for planetary and interplanetary probes. The rest of the interest is centred around elliptical orbits in which case the spacecraft is referred to as a satellite.

Orbit classifications

There are three parameters of primary interest in the orbit classification. The first one is the inclination (i) of the orbit plane with reference to the equator. Depending upon this inclination, orbits are known as equatorial, polar or inclined orbits. The second parameter is the eccentricity (e) which is a measure of the deviation from the circular shape. Near circular orbit refers to a very low (e), while elliptical orbits refer to the high eccentricity orbits, with transfer orbits falling in-between. The third parameter is the semi-major axis (a) of the ellipse, which represents the mean distance of the satellite from the centre of the earth. This is also a measure of the energy of the orbit, higher a meaning higher energy. From this point of view, orbits are classified as near earth orbits, low earth orbits, and high earth orbits. This (a) incidentally also decides uniquely the period of the orbit. This period increases from about 90 minutes for near-earth orbits to about 27 days for moon's orbit (Fig. 2).

From the application point of view, two orbits are of special importance. First one is the stationary orbit used by most of the communication satellites. It is a special case of circular, equatorial orbit with a period of one sidereal day. In this case, the rotational speed of the satellite coincides with that of the earth and it appears stationary from any group.

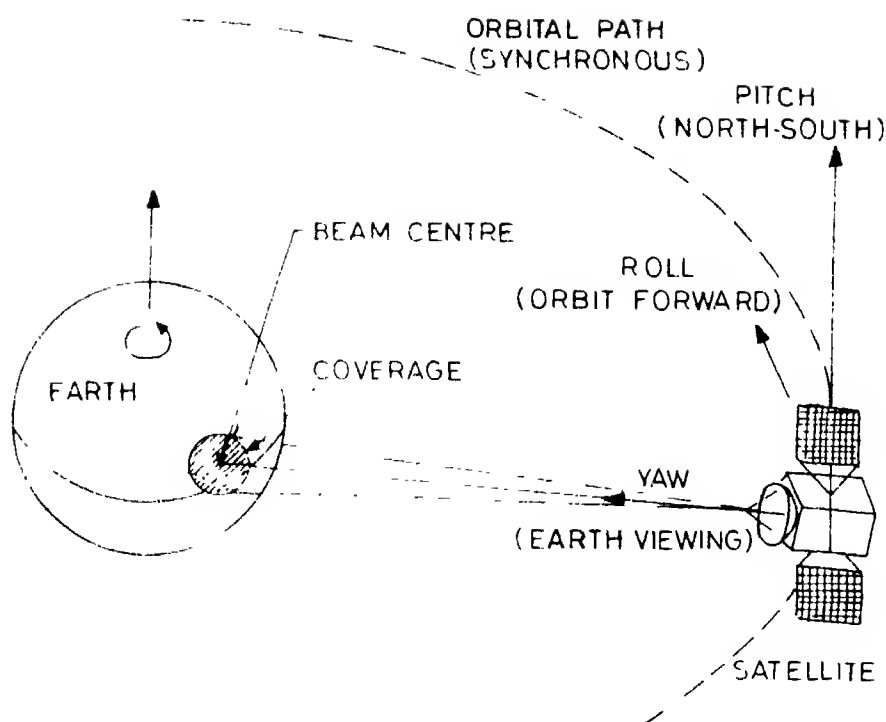


Fig. 1 Satellite orbits

spot. Once aligned, the ground antenna can receive signals continuously from the satellite without further steering or tracking. This being a great advantage, it is the most crowded orbit today, with more than 100 active satellites occupying different positions on it. Since the satellites here remain stationary with reference to the earth, they are specified by the longitude of the sub-satellite point (e.g. 94°E for INSAT-1B).

The second most popular orbit is the sun-synchronous orbit. This is a special class of near-polar orbits which maintains its inclination with reference to the sun. This has been fully exploited for the purpose of photography and remote sensing missions. The typical Landsat (USA) orbit is inclined at 96° to the equator. The satellite makes 14 orbits/day reappearing at a given point at a particular local time.

Besides these, there are a variety of orbits in use due to different considerations such as launch vehicle constraints, launch site location, ground stations available and particular mission requirements.

Station keeping

The actual orbits, contrary to these simple models, are perturbed by many factors. They include self-propulsion and manoeuvring, non-symmetry in the gravitation potential

of the earth, lunar, solar and other planetary gravitational forces, drag and radiation effects, magnetic field effects, relativistic effects, etc. A mission needing precision targeting has to take care of all these effects.

The major practical difficulty arises from orbit decay, which is associated with the loss of kinetic energy mainly due to drag effects of the rarefied atmosphere. This effect is pronounced for near-earth and low-earth orbits. Unless compensated for, this results in eventual lowering of the orbit which makes the satellite enter the dense atmosphere and burn up. In fact, below 150 km altitude, the satellite life is only a few hours. At about 1000 km altitude these effects are rather moderate. At synchronous orbits, the drag effects are negligible.

The total effect of all these perturbations is to shift the relative or desired position of the satellite, necessitating a corrective mechanism to restore the same. This process of correction is called 'station keeping'. It is done by means of small thrusters, powered by compressed gas, which give known impulses in the right direction to compensate for the energy loss.

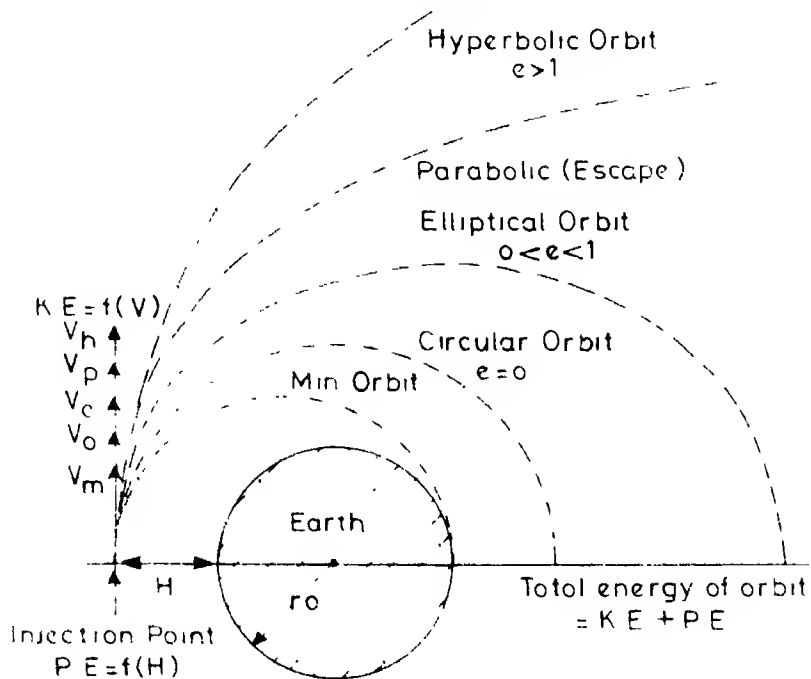


Fig. 2 Periods and velocity in orbit

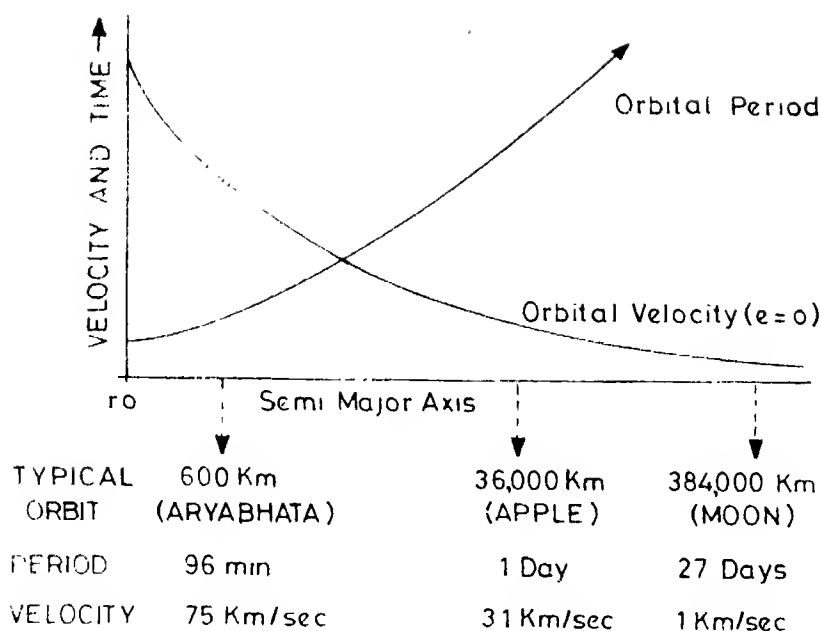


Fig. 3. Attitude control

Attitude control

The different satellite missions, in addition to a particular orbit, need particular orientation in space. For example, the antenna needs to point to an earth station in a communication satellite, or the camera needs to scan a certain area on earth on a remote sensing satellite, or a detector needs to point to a particular location in the sky in a scientific satellite mission.

Similar to the Newton's law on relating linear momentum to force, we have a relationship connecting the change in angular momentum to the applied torque. This forms the basis of the satellite attitude control which aims at orienting the satellite axis to a desired pre-determined direction.

Without control, a satellite has no fixed orientation and even a small disturbance can make it tumble. Spinning gives it stability such that the orientation of the spin axis remains fixed in space. In case of a two stage unguided rocket, for example, spinning helps to maintain the direction in case of a small disturbance. Often this is not enough and we need also to control the orientation of the spin axis. For example, in case of

certain space probes the detector needs to be pointing in a fixed direction (as in a photographic mission with a spinning satellite). In such cases spin axis may have to be oriented permanently perpendicular to the orbital plane.

A polar mission with a camera, such as Landsat, needs to point

always towards earth. A synchronous communication satellite with a shaped antenna also has a similar requirement. Control on all the three axis orientation is needed for these advanced missions. Such a requirement also exists for guided missiles and most of the launch vehicle stages need accurate trajectory control.

Stationary communication satellites with an earthpointing antenna use a special technique known as 'dual-spin'. The main body uses the spin mode with spin axis normal to the orbit plane. Only a small portion with the antenna is mounted on the top of a platform which is de-spun at a rate such that it always points towards the earth.

In the attitude control of a stationary communication satellite using three axis control, the rotational motion is measured in terms of the movement of the body axis called yaw, pitch and roll axis, defined similar to that of an aeroplane. In this case, the body axis and the desired orientations (bracketed) are shown in Fig. 3. For the desired ground coverage, it is necessary to station the satellite at the pre-determined

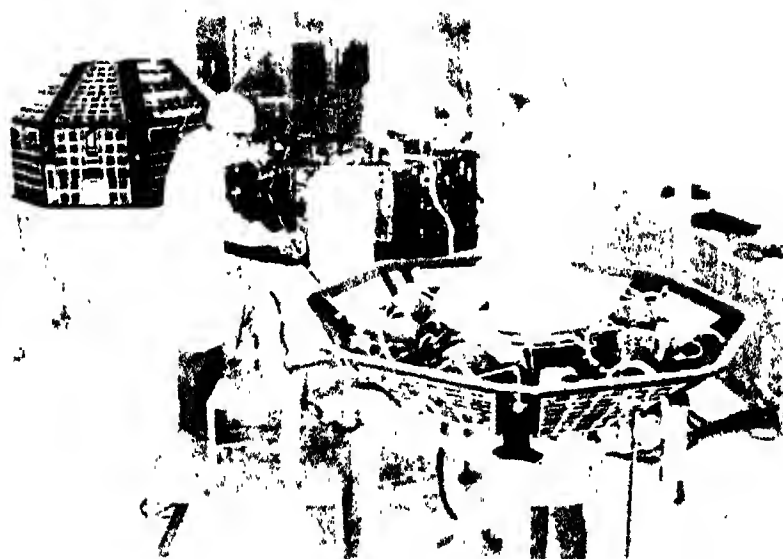


Fig. 4. Inside of Aryabhata showing housing of control system

position and orient the axis as shown. That will adjust the beam centre at the required position on the ground. However, perturbations as mentioned earlier affect the attitude of the satellite. That, in turn, generates error or a mismatch. For a given position, the errors in these axis locations shift the actual beam centre on the earth. It can be seen that the change of orientation of 0.1° in roll axis will shift the beam centre by 65 km in North-South direction. Similarly, a 0.1° error in pitch axis will shift the centre by similar amount in East-West direction. For the shaped antennas, the yaw error will make the coverage rotate about the beam centre. Hence,

an appropriate control system, basically generating controlled torques is housed in these satellites to control the axis in the desired directions.

Spacecraft orbital manoeuvre and attitude control are a part of the sophisticated practice of space technology. Their understanding, which has been the key factor behind the numerous successful missions, took time to develop. This knowledge would grow and excite ever hungry minds trying to unravel the mysteries of the Universe.

Further reading

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LETTERS (Continued from page 436)

pitta', a migratory bird from the foot of Himalayas to the south, even upto Sri Lanka, that attracts considerable ornithological interest owing to its colour. This bird is comparatively smaller than our common Indian Mynah. As a matter of fact, one can easily notice olive brown, yellow, blood red, blue, green, black and white (white eyebrow patch) colours on its feathers. The colour also exhibits enchanting shine in sunlight. This peculiar colour pattern protects it from predators to a great extent while resting on the small branches of trees and searching for food (millipede) on the ground. But there is no difference in colours between males and females. These birds are seen in abundance during September to November at Point Calimere in Tamil Nadu.

Reference

Journal of the Bombay Natural History Society, Vol. 77, No. 1

V. TAMILMANI
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Ribosomes

Sir, I read the article 'What is new in ribosomology' by D.P. Burma (S.R., March 1984) with absorbing interest. Surprisingly, the author failed to distinguish the procaryote from eucaryote (page 103, it should be a eucaryote). Actually, procaryote does not possess organised nucleus and other cell organelles like chloroplast, mitochondria etc. On the other hand, eucaryote is equipped with a nucleus and other cell organelles. Similarly, the yeast possessing a well defined nucleus is a unicellular organism instead of being multicellular. Hence, it is included among eucaryotes.

SHAMIM A. ANSARI
Research Fellow
Department of Botany
AMU, Aligarh

II

Sir, Thank you for publishing the article 'What is new in ribosomology' by D.P. Burma (S.R., March 1984). In the article, the author has grouped all unicellular organisms as procaryotes which is not correct.

Prokaryotes include only simple small cells comprising blue-green alga, bacteria and viruses. They lack nuclear membrane and clearly defined membrane limited organelle such as mitochondria, chloroplast, Golgi bodies and lysosomes, and do not have elaborate structure of chromosomes. The author has also defined yeast as multicellular organism (p. 103). Actually it is a unicellular organism but is not a prokaryote.

GIRINDRA KALITA
Gauhati University
Gauhati (Assam)

I am sorry that the mistake crept in inadvertently. In the draft of the manuscript it was written 'Prokaryotes are usually unicellular organisms'. In the final manuscript the word 'usually' was somehow dropped out. I am thankful to Kalita and Ansari for pointing out the mistake.

D.P. BURMA
Department of Biochemistry
Banaras Hindu University
Varanasi-221005

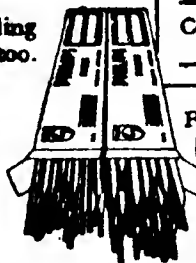


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NEUROLOGICAL ENDOCRINOLOGY: THE COORDINATING MECHANISM

A.D. DIWAN

The nervous and endocrine systems are integrative in nature for they provide the organism with sophisticated external and internal sensing devices which feed information into the central nervous system for appropriate responses of the target systems

THE production and dispersal of chemical substances within an organism which subserve definite integrating and coordinating roles, and thereby supplement the activity of the nervous elements, are characteristic of all living things. Such substances may be referred to as chemical coordinators. In short, every substance which enters body fluids from the external environment or from constituent cells of a higher organism contributes to the normal composition of the internal medium is a chemical coordinator. Such chemical coordinators may be more restricted in their region of origin within the body and adaptively participate in a specialised activity within the organism. Many groups of higher organisms have specialised glandular cells, tissues or organs which produce such coordinatory substances for the organism as a whole.

The most important point to emphasize for comparative physiological purposes is that in a number of phyla and classes of animals special chemical substances are produced which are essential to normal development and functional integration of the body. The points of origin within the organism, the specific chemical nature of the hormones and the methods of transport are secondary in importance. The nature of the resultant effects depends as much on the nature of the reacting tissues as on the chemical properties of the circulating

hormone. The ability to maintain constancy is observed to a high degree of development in the mammals through the integration of nervous and hormonal systems and to a lesser extent in the lower vertebrates. The invertebrates also have similar mechanism of regulation, although they are considerably less exacting. The two major integrative systems of the body, the nervous and endocrine systems, are intimately interrelated functionally. The nervous and endocrine systems are integrative in nature, for they provide the organism with sophisticated external and internal sensing devices which feed information into the central nervous system for analysis and integration, and in turn orchestrate the necessary target systems to conduct the appropriate responses efficiently. The nervous system is characterized by its ability to respond to stimuli with high speed and short duration. Complicated chains of interconnected neurons are necessary for the transmission of transient impulses, together with the highly localized production of chemicals such as adrenaline and acetylcholine which are rapidly destroyed. The endocrine system uses circulating body fluids to carry its chemical messengers to more or less specific target organs. These chemicals take time to build up to an effective concentration, and consequently must have a longer biological life than chemicals of the nervous system before they are even

usually destroyed or excreted. Hormones are consequently well suited to exert their effects over extended periods of time, and endocrine system controls long-term processes within the body. Thus the endocrine system, when compared to the nervous system, is involved in responses that are slower and long lasting. Since the nervous system is the sole sensing arm of this reflex, the endocrine organs can be referred to as effector units of the nervous system, the link between the two is therefore the seat of integration. Thus, in all metazoa the nervous and endocrine systems so coordinate the activities of various organ and tissue in the body that the animals function as individuals.

Why animals have both nervous and endocrine systems, each performing a coordinatory role, is a matter of considerable interest. The nervous system makes possible the rapid adjustment of internal processes to environmental changes. Impulses are transmitted and are channelized and directed specifically towards particular loci in the organism. As organism evolved, it became imperative that the muscular system in particular be perfected so that quick coordination is possible. The swiftness required in adjustment of this is far beyond the power of a purely endocrine mechanism. Hormones or similar types of chemical coordinators have to be released by the organs that synthesize them and be transported by the circulation and

transmitted through the tissues before reaching their appropriate target organs. Many of the hormone molecules are large and complex and it is probable that they pass slowly through the walls of blood vessels. Thus the two systems are functionally interrelated, one is primarily concerned with rapid adjustments and the other with processes that require duration rather than speed. It must not be supposed that the nervous system functions quite independently of the endocrine system. But it is likely that central nervous activity in most animals is strongly affected by hormones. For example, a mature female grasshopper will move towards and mate with a courting male. An immature female avoids, and will even fight with male if male persists in courtship. The hormone compliments of the two females cause their central nervous system to interpret the same information differently and to initiate quite opposite reactions. But the reverse is also true, i.e. hormone production and release is dependant upon the nervous activity. Almost all the animals have to respond developmentally to environmental changes throughout the year. In unfavourable conditions they undergo hibernation or migration* or overcome them by other changes in behaviour or physiology. In favourable seasons most of the advantage is taken for rapid development and multiplication. Even slight fluctuations, such as shortage of food or the absence of suitable mates can have drastic effects upon development. The colour change in many crustaceans is brought about by alternations in the shade of their immediate environment. Similarly the act of mating in a female insect can accelerate the development of her egg. The change in day length of a day can control the on-set of metamorphosis in annelids. All these developmental and physiological responses result from changes in the concentrations of circulating hormones caused by nervous impulses originating in the stimu-

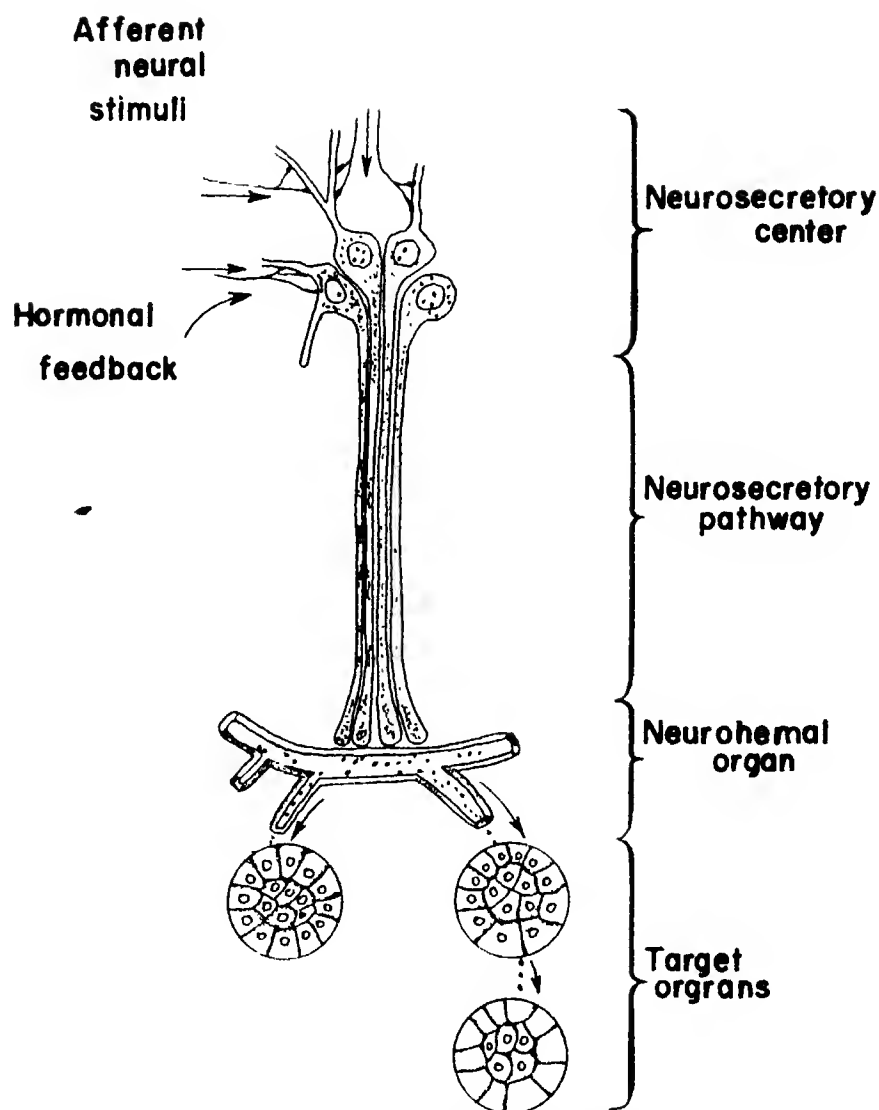


Fig. 1. A typical neurosecretory system (From Scharrer, E.E. and Scharrer, B., *Neuroendocrinology*, Columbia University Press, New York, 1963)

lation of particular sense organs. Thus the nervous and endocrine systems are strictly interdependent.

There are very few endocrine glands which are richly innervated by the nerve fibres. But the anterior pituitary gland which has been long known to produce a number of hormones and controls the activities of other endocrine glands contains very few nerve fibres. The question then is: How the nervous activity controls endocrine functions. In view of more recent observations, opinions about the possible endocrine function of nervous tissue have been completely reversed. It is generally now accepted that the nervous

systems do have the ability to produce hormones. It is now proved that the central nervous systems of arthropods and vertebrates contain particular endocrine cells. These cells are morphologically similar to neurons, with axons, dendrites, nissl bodies and neurofibrillae. They are also able to transmit nervous impulses, but they differ from other neurons in two important respects; their axons do not innervate effector organs such as muscles, nor make synaptic connections with other neurons, and they manufacture materials often visible in stained sections of nervous tissue, which are released from the ends of the axons and exert a biological effect

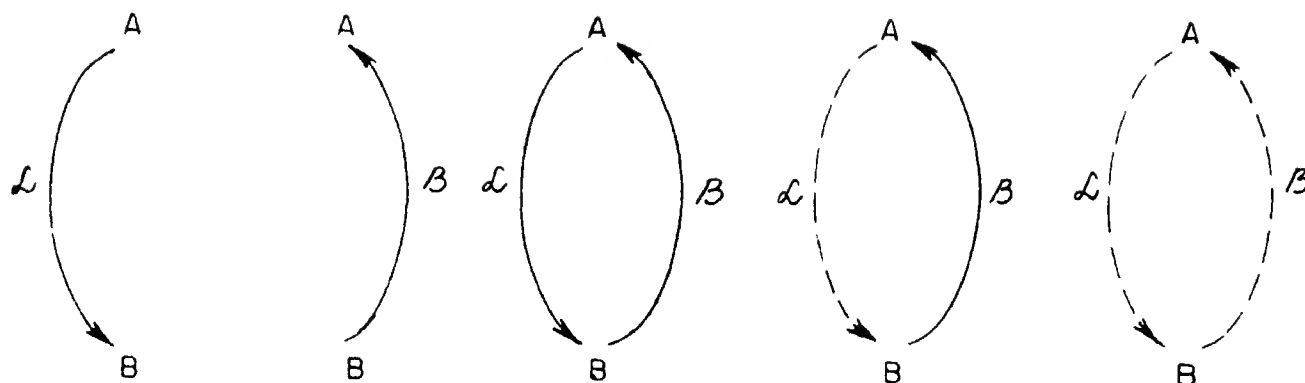


Fig. 2. Different phases of hormonal feedback (After Scharrer, 1963)

some distance away. So these cells are the neurons which also produce hormones and are consequently called neurosecretory cells. In many animals, the neurosecretory cells are often clumped into groups which are very conspicuous features of the central nervous system observed with proper staining procedures. The ends of the neurosecretory cell axons are usually swollen and the secretory material which is formed in the cell body can be stored here before being released. The swollen axon terminals lie outside the nervous system, usually closely associated with the circulatory system which carries the neurosecretory hormones around the body. The axons of these cells run in more or less well defined tracts and often terminate in a special end organs outside the nervous system. Since these structures are directly associated with blood vessels, they are generally termed as "Neurohaemal organs."

Neurosecretion

The distinction between the endocrine and nervous systems has diminished in recent years. The concept of the two systems working together to provide the organism with an integrative network has emerged. This has been favoured by the observations that the nerve cells synthesize, transport and secrete chemicals, which is

broadly the definition of neurosecretion. Nerve cells generally play the dual role of conduction of excitation and secretion of such neurohumoral materials or neurotransmitters, e.g. acetylcholine, adrenaline,

noradrenaline and 5-hydroxy-tryptamine which have important roles at interneuronal and neuromotor junctions. Since our concern is not with this aspect of neurosecretion, it will not be discussed here. Bragmann,

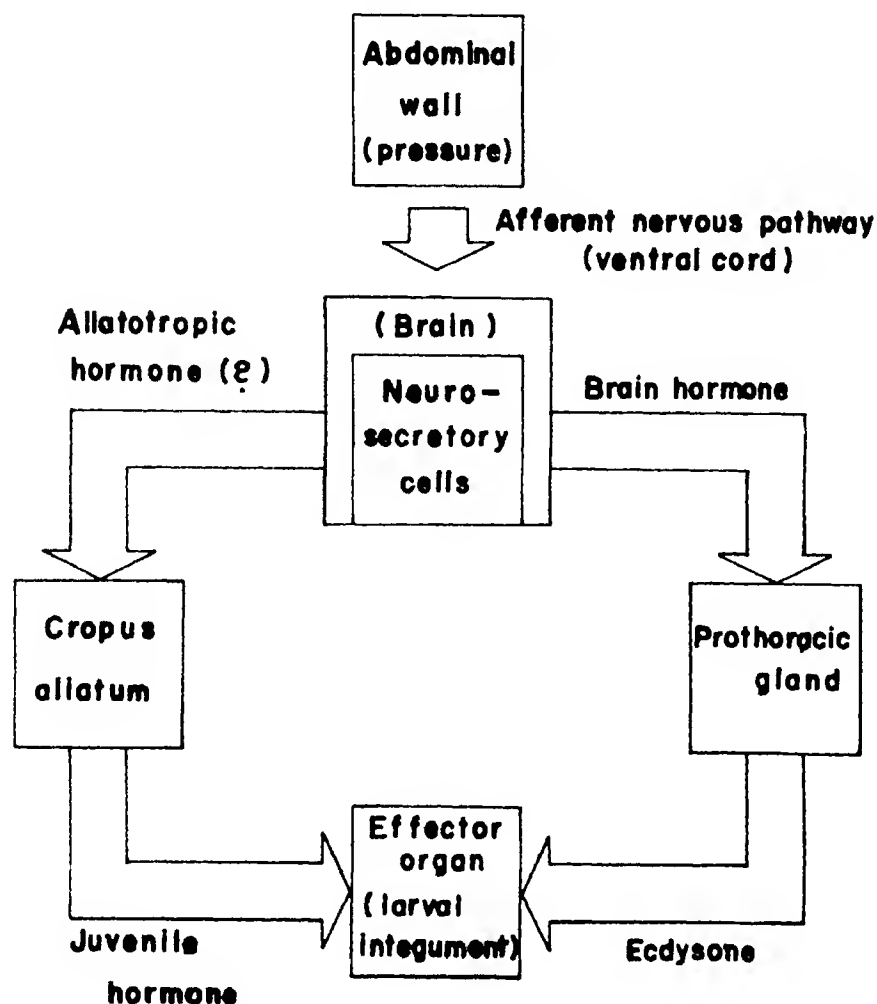


Fig. 3. Neuroendocrine control of moulting in insects (After Scharrer and Scharrer, 1963)

Hanstrom and the Scharrers have used another concept of neurosecretion which is most commonly accepted. This concept refers to a nerve cell containing prominent, stainable inclusion which appears to represent hormonally active secretory material, synthesized within the cell body, often transmitted via an axon to be released from the cell at some distance from the site of the synthesis and remaining active for longer period of time. Neurosecretory cells are essentially similar in both invertebrates and vertebrates, although, it is possible that the invertebrate cells may lack dendrites and it is not yet definitely proved that they can transmit nervous impulses. The material released from the neurosecretory cells is largely protein and reacts histologically and histochemically in much the same way whether it is produced by invertebrate or vertebrate neurosecretory cells. The electron microscope has provided us an ultrastructure of the neurosecretory cells. The basic neurosecretory product, the elementary neurosecretory granules, appear to vary in electron density, are membrane bounded, average between 1,000 Å and 3,000 Å in diameter and have their origin in the golgi apparatus of the neurosecretory cells. Knowles suggested two categories of neurosecretion, common in both vertebrates and invertebrates, which appear, at the ultrastructural level: Type A with granules greater than 1,000 Å in diameter and peptide in nature and Type B with granules less than 1,000 Å in diameter and with a nonpeptide or possibly an amine secretion. Type A is represented by the more commonly reported category of neurosecretion (Fig. 1.)

Some neurosecretory cells produce electron-transparent vesicles both in invertebrates and vertebrates. The dense spheres originate in golgi apparatus of the cell bodies in a manner similar to protein droplet formation in other endocrine and ordinary gland cells. In vertebrates

the protein material synthesized by neurosecretory cells is called neurophysine which is the actual carrier of hormones. This is true of all vertebrate neurosecretory cells, but whenever the same applies to all invertebrate cells neurosecretion is problematical.

The endocrine organs are divided into two categories: those which are derived from embryonic ectoderm, mesoderm and endoderm layers, are called epithelial endocrine glands, and those which are derived from nervous tissue. Except the adrenal medulla and posterior pituitary all the endocrine glands and tissues of typical vertebrate are included in the first category. The adrenal medulla and posterior pituitary which developed from a transformed synaptic ganglion and of the brain respectively are therefore included in second category. But now it is confirmed after investigation that posterior pituitary is a neurohaemal organ as groups of neurosecretory cells are found in hypothalamus of the brain. Thus the posterior pituitary is quite a different endocrine organ from the adrenal medulla. In some vertebrates a second major neurosecretory system is situated at the posterior end of the spinal cord which is termed as caudal neurosecretory system. The functional significance of the caudal neurosecretory system remains obscure, but there are suggestions that its secretion may be involved in sodium exchange and gas metabolism.

In the vertebrate animals, epithelial organs developed from transformed nerve ganglia and neurosecretory cells often with well formed neurohaemal organ are all present. Even in complex animals like the arthropods, the number of epithelial endocrine glands is much less than in the vertebrates, and in most other invertebrate groups they are absent altogether. So the endocrine mechanisms in the invertebrates are usually simpler than the vertebrates. Because of the small number of epithelial endocrine glands in invertebrates, neurosecretory

mechanisms assume great importance. However, many problems are associated with the determination of the function of neurosecretory system.

The classical endocrinological experiments to determine the functional aspects of neurosecretory system involves the removal of a suspected endocrine gland followed by its subsequent reimplantation at a different site in the body. If the consequences of removal are reversed and brought back to normal on reimplantation, then it is established that a hormonal mechanism is involved. But when a neurohaemal organ is removed, the cut ends of the neurosecretory axons may still release a hormone, sometimes in an uncontrolled manner. There is a possibility of regeneration of a new neurohaemal organ, so that the effects of deficiency of neurosecretory hormones may not be severe. When neurosecretory cells which supply neurohaemal organ are destroyed, the stored hormones within the organ may be released for some time after the operation. In some animals, a well defined neurohaemal organ may be absent, but the neurosecretory cells are present throughout the central nervous system. Some neurosecretory hormones are not released into the circulatory system, but are transported axonally directly to their target organs. It is rather difficult to determine the exact function of such neurosecretory mechanism because of the difficulty of extracting and testing biological materials from individual cells.

Neuroendocrine integration

The meaning of the term "Neuroendocrine integration" can be best explained by the following hypothetical situation. Suppose the endocrine organ 'A' after stimulation releases a hormone α , then its increasing titer in the blood stimulates endocrine organ 'B' which produces and releases hormone β . As hormone continues to stimulate organ 'B', the increasing blood concentration of hormone β

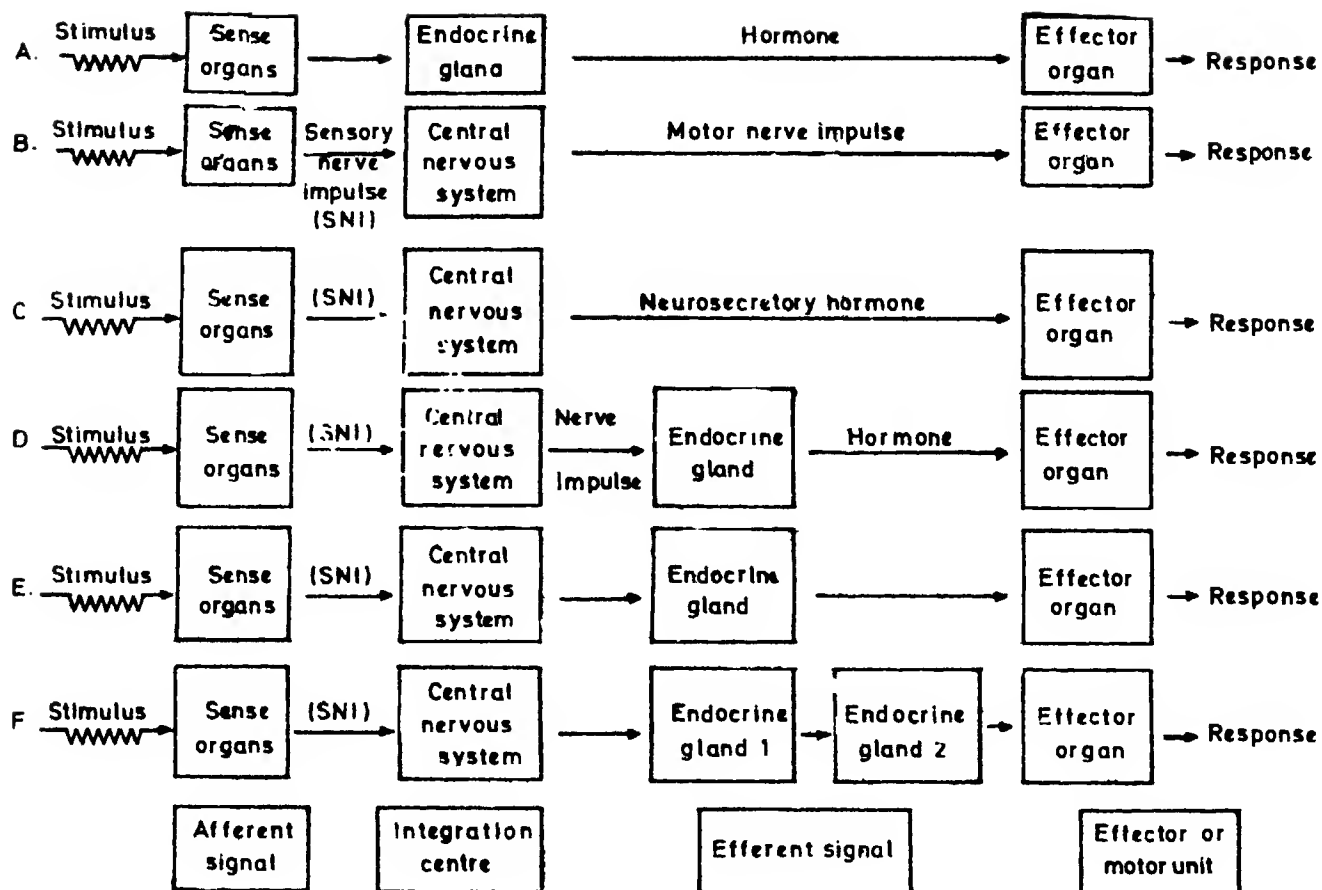


Fig. 4. An expansion of the reflex arc showing six possible means of activating a motor unit following the receipt of a stimulus by a sensory organ (After Frye, 1967)

begins to exert an inhibiting effect on organ 'A'. Organ 'A' reduces its output and naturally stops to release hormone α . Thus hormone β not only serves its particular function but also regulates its own production by its inhibitory effect on organ 'A' (Fig. 2).

Here the environmental condition may affect in such a way that either organ 'A' should continue to stimulate organ 'B' irrespective of the blood titer of hormone β or should stop releasing its hormone although organ 'B' may have hardly begun to respond to stimulus of α . In order to accomplish such an adjustment, the feedback cycle is necessary. This point can well be illustrated by the control of ovarian function in mammals. The mechanism for release of gonadotrophins was originally conceived as a simple feedback of gonadal steroids to the pituitary. But, if this was the

only determining factor, then external and internal conditions such as photoperiods, availability of food, social contact, etc. could not affect the reproductive cycle. There must be channels through which these modifying influences enter the control system and become integrated with the ovarian feedback mechanism. This integration can take place only in the central nervous system. So the ability of an organism to receive environmental signals, to respond to those which are important, to disregard the irrelevant and less important ones, and to retain normalcy throughout the body is due to integrative action of the central nervous system. This essentially involves three interrelated units: afferent pathways, integrative centres and efferent pathways.

1. *Afferent pathways.* Afferent

pathways are known to play a very important role in control of endocrine functions. The receptor cells in the body are the prime movers in any reflex arc. They send their signals by way of afferent axons into a particular ganglion. This sense of reception can originate in special sense organs like photoreceptors, chemoreceptors and acoustic apparatus or also from touch, pain and temperature receptors. Retinal fibers of the eye, for example, carry impulses resulting from the increase of total illumination in spring, which in birds stimulates gonadal growth. Another important source of stimuli for the release of hormones controlling reproductive function lies in the olfactory apparatus. Stimuli may also result from changes in the internal environment, i.e., pH, osmolarity, chemical composition of blood or from hormonal feedback. In

insects also, a considerable information has been obtained regarding the control of endocrine function by afferent nervous pathways. For example, in nymphs of the blood sucking hemipteran *Rhodnius* sp., initiation of the moult cycle depends upon nervous stimulation having its origin in stretch receptors in abdomen. After a meal of blood in a sufficiently large quantity, the receptors are activated and through the ventral nerve cord stimulate the neurosecretory cells of the brain to produce their appropriate secretions. In certain species of cockroaches tactile stimuli resulting from mating and proprioceptive impulses caused by pregnancy reach the brain by way of the ventral nerve cord (Fig. 3).

2. *Integrative centres.* By way of neural and vascular routes nervous and chemical afferent stimuli converge on the central nervous system, which in turn transmits excitatory or inhibitory signals to the target organs. For example, afferent nervous, hormonal and direct stimuli, converge on the nerve centers which issue efferent messages concerned with the respiration, hunger, thirst, temperature control and many other basic functions. With the changes in CO₂ content, glucose concentration or temperature of the blood, the neurons get directly stimulated. Nervous impulses originating from the peripheral receptors have access to these centres via synapsing neurons. The sum total of the information received results in decision to increase or decrease respiratory rate, to sweat or to shiver, to store or to mobilize glycogen. The portion of the nervous system which receives such impulses and translates them into effective nervous or hormonal output signals has been called final common pathway. The neurosecretory cells constitute the link between central nervous system and organs of internal secretion. Their dual character as nerve and gland cells enables them to receive nervous impulses from other neurons and stimulate or

inhibit the organs of internal secretion by dispatching chemical messages.

3. *Efferent pathways.* Neurohormones may act either directly on the target organ or they may first act on endocrine tissue which in turn influences the target organ. Fryc has given six pathways to show possible relationships between neural hormonal components (Fig. 4).

First order of neuroendocrine reflex

Here the neurosecretory cells exert direct control over target organs. Inhibition of gonadal maturation in annelids and crustaceans and stimulating smooth musculature or promoting water conservation by the kidney in vertebrates are the examples of first order of neuroendocrine systems. The agents are released from neurohaemal organ into general circulation, proportionately in large quantities to maintain effective concentration. The possibility also exists that the stimuli may act directly on neurosecretory cells within the central nervous system, which would make scheme C more like scheme A (Fig. 4).

Second order of neuroendocrine reflex

The incorporation of one non-neuronal endocrine organ between the neurosecretory cells of the central nervous system and the final target organ represents this second order reflex. For example, in case of *Rhodnius* sp., as described previously, the neurohormones influencing the prothoracic glands and corporallata to subsequent release of ecdysone and juvenile hormones respectively illustrate the second order of neuroendocrine reflex. This additional non-neuronal structure generally is in close association with the neurosecretory cells or processes of such cells. Such incorporation of non-neuronal structure facilitates efficient transfer of information which might

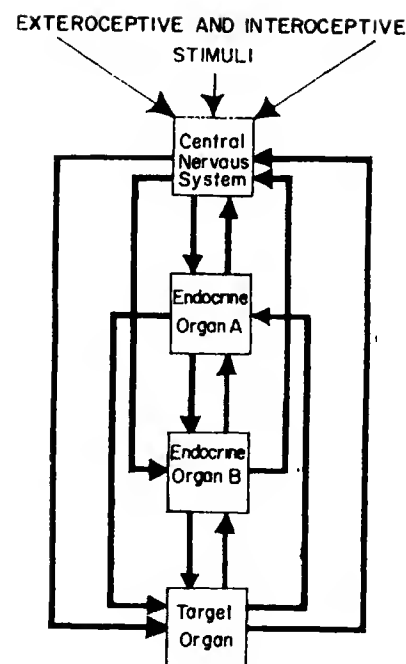


Fig. 5. Possible neuroendocrine interactions to include the First, Second and Third order systems

not be the case if the active components entered the vascular system directly.

Third order of neuroendocrine reflex

The incorporation of two non-neuronal endocrine organs between the neurosecretory cells of the central nervous system and the final target organ illustrates this third order reflex (scheme F in Fig. 4). For example, the role of the anterior pituitary in the case of adrenal cortical stimulation. The corticotropin releasing factor (CRF) produced by the hypothalamic neurosecretory cells does not enter the general circulation to act directly on the adrenal cortex. It is carried by hypothalamic portal vessels to the adenohypophysis where it stimulates the release of adrenocorticotrophic hormone (ACTH). The ACTH reaches the adrenal cortex causing it to build up its secretory apparatus and to release corticoids (second order of neuroendocrine reflex). Nor is this the limit of such sequences but in the third

(Continued on page 490)

THERMONUCLEAR POWER: AN ANSWER TO ENERGY CRISIS

A.V. NARASIMHAM

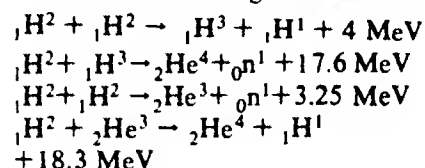
The main problems in practical application of fusion power lie in the containment of the extremely hot plasma and maintenance of its very high temperature

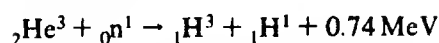
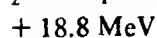
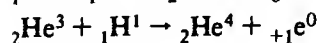
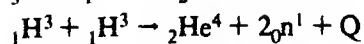
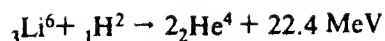
EVEN though considerable interest is shown in the use of uranium and thorium as nuclear fuels, they cannot present a real solution to the energy problem, as the total amount of energy available from these fuels may not be more than that available from coal. An alternative form of energy may be thermonuclear power which can be obtained from nuclear fusion reactions, which are also known as thermonuclear reactions. The origin of these reactions was first traced by a group of astrophysicists in the interstellar space, especially in the interior of the sun. These interstellar reactions are essentially fusion reactions, i.e., two elements (generally light) fuse together to form a heavier element. During this process a small amount of mass (Δm) is converted into energy (ΔE) in accordance with Einstein's relation ($\Delta E = (\Delta m)c^2$). This means that mass and energy are interconvertible. The principle of conservation of energy has now become the principle of conservation of mass and energy put together. However small Δm may be, enormous amounts of energy are released, due to the large value of $c^2 = 9 \times 10^{20}$ CGS units, where c is the velocity of light. Fusion is opposed to fission, where a heavy element like uranium is broken up into two pieces by the absorption of slow neutrons. Energy released by fission process also is given by the aforesaid

Einstein's relation. However, the percentage of conversion of mass into energy is much higher in fusion process than in fission process. Most of the present day nuclear energy programs—heavy water reactors, enriched uranium reactors, breeder reactors, etc.—involve fission process. The atom bomb is a fission bomb. The hydrogen bomb is a fusion bomb. This is an uncontrolled thermonuclear device, leading to an explosion, i.e., it works like a bomb and the energy output of the fusion reactions cannot be controlled, while, on the other hand, the energy output in a fission reactor can be controlled. The essential problem of thermonuclear research is therefore to control the energy released by fusion reactions so that a nuclear fusion reactor can be built for peaceful uses.

Why is it that nuclear fusion reactions involve essentially light elements? In principle, two heavy elements also can be fused if proper conditions are available. However, the fusion of two heavy elements (to form a new element) is much more difficult than the fusion of two light elements as the Coulomb repulsive force between protons of two light elements is much less than that of two heavy elements. This is essentially the reason why fusion of two heavy elements is almost an impossibility. Fusion of even two light elements like

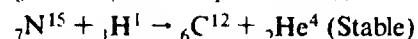
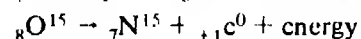
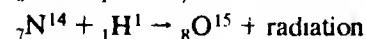
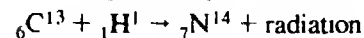
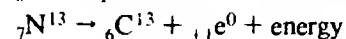
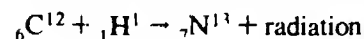
hydrogen or deuterium requires unimaginable temperatures like those that exist in the interior of the sun, about 10^8 degrees Kelvin. At these temperatures the pressure of the reacting gases is about 5×10^6 atmospheres. Such temperatures and pressures are achieved in the hydrogen bomb. Large amounts of thermonuclear fuels, namely, hydrogen, deuterium, etc., are available in nature. Natural hydrogen contains 0.0156% of deuterium and 1 in 10^{17} of tritium in atmosphere, in oceans, etc. However, nuclear fission reactors, which operate at ordinary temperatures and which do not pose problems of control, have become the only source of present day nuclear energy for peaceful purposes, even though there are many difficulties involved in the operation of these reactors. The nuclear wastes and various byproducts of these fission reactors pose great problems of health hazards. Preparation of nuclear fuels, enrichment of natural uranium, preparation of heavy water are all very expensive and laborious processes, while the fission reactor itself is made very heavy due to the presence of a large amount of moderator. So, if the control of a nuclear fusion reactor can be achieved, generation of energy by nuclear fusion will be more economic and attractive, in view of the high degree of availability of the fuels, i.e., hydrogen and deuterium. Moreover fusion reactor does not pose problems of radiation hazards, as the end product is usually stable helium(4). There may be some possibility of direct conversion of fusion energy into electrical energy as very high electrical currents are generated in the fusion plasma. Some important fusion reactions are given below :





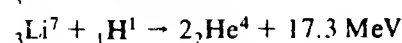
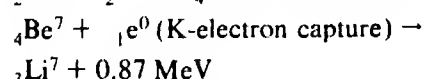
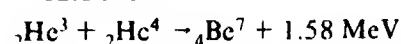
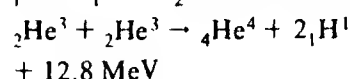
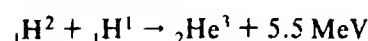
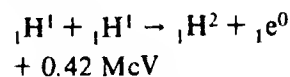
So large amounts of deuterium, which is abundantly available in oceans, is converted into stable helium(4), while helium(3) and tritium are formed during the process of fusion. The power output of a fusion reactor may be about 50 times more than that of a fission reactor. Calculations show that the oceans of the world can yield about 2.63×10^{10} tons of deuterium. Gasoline, one of the best chemical fuels, provides about 6 kWh of energy/pound, while deuterium provides about 4×10^7 kWh of energy/pound.

It is believed that the sun which emits energy at a rate of about 3.8×10^{33} ergs/second can do so even for billions of years, and is a favourable place for thermonuclear reactions. This calculation is based upon the surface temperature of the sun, which is about 5760 K. No other reactions can explain the release of enormous amounts of energy from the sun. There is a constant conversion of hydrogen into helium due to these reactions. Hans Bethe and Weizsacker suggested in 1938 a series of reactions, known as Carbon Cycle, to account for the thermonuclear reactions in the sun, which can be stated as follows :



So, there is a continuous conversion of hydrogen in the sun into helium (4) with the emission of positrons and enormous amount of energy, including radiant energy, while carbon serves as a catalyst. It is believed that in every second 564×10^6 tons of hydrogen in the sun is converted into 560×10^6 tons of helium(4). The difference of 4 million tons of hydrogen is comple-

tely converted into energy in accordance with Einstein's relation. An alternative mechanism for the thermonuclear reactions that go on in the interior of the sun is suggested as follows :



So, an enormous amount of hydrogen is converted into stable helium(4) with the emission of large amounts of energy. The overall reaction can be represented as $4{}_1\text{H}^1 \rightarrow {}_2\text{He}^4 + 2{}_+1\text{e}^0 + 26.7 \text{ MeV}$. About 2 MeV of energy is released for each electron-positron annihilation.

Thermonuclear fuel

In the above examples, are various fusion reactions which give enormous amounts of energy. However, an important property of a nuclear reaction is its probability (or cross-section), in addition to energy output. A single reaction may give a large energy output. But, if its probability is very small, then the total output (or yield) from the reacting gases will be very low. So, from the point of view of power output, a few fusion reactions must be chosen and examined carefully, and then selected striking a balance between their probability and energy output. Such studies form an important aspect of thermonuclear research. According to these investigations, it appears that deuterium, tritium and lithium are the best choices for thermonuclear fuels. The so-called Deuterium-Tritium reaction (an equimolar mixture of deuterium and tritium) has the highest cross-section among all known fusion reactions. This can be written as

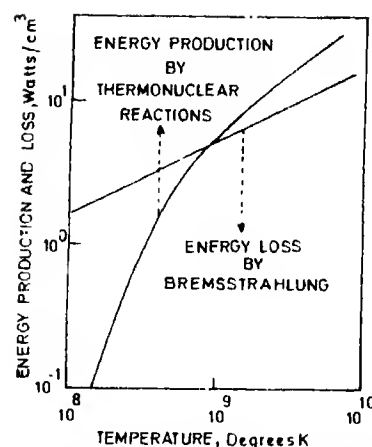
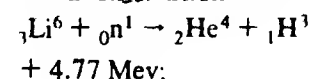
$${}_1\text{H}^3 + {}_1\text{H}^2 \rightarrow {}_2\text{He}^4 + {}_0\text{n}^1$$


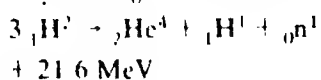
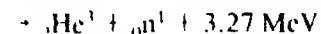
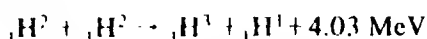
Fig. 1. Production and loss of energy in a thermonuclear reaction—deuterium gas 10^{15} nuclei/cm³

+ 17.6 MeV. The reactions between two Deuterons (d-d reactions) and between two Tritons (t-t reactions) are also studied and it is found that their reaction cross-sections are about 100 times lower in the former case and much less in the latter case. In short, it appears wise to use tritium for a thermonuclear bomb, the technological success of which has already been established, rather than a thermonuclear reactor the technological success of which has not yet been established. Neutrons can be more economically used for the production of plutonium (${}_{92}\text{U}^{238} + {}_0\text{n}^1 \rightarrow {}_{92}\text{Pu}^{239}$), an important fuel for atom bombs as well as fission reactors, rather than for the production of tritium. The technological feasibility of a fission reactor has already been established, while it is not the case with a fusion reactor. Lithium, in spite of its fairly good abundance, seems more suitable for a fusion bomb rather than for a fusion reactor. The following reactions take place in a fusion (hydrogen) bomb: The formation of triton



${}_1\text{H}^3 + {}_1\text{H}^2 \rightarrow {}_2\text{He}^4 + {}_0\text{n}^1 + 17.6 \text{ MeV}$ requires a high neutron flux. So, a high initial flux of neutrons is required to make these reactions self-sustaining or to build a chain reaction. In the

case of a thermonuclear bomb, which lasts only for a short duration, such a high initial neutron flux is built by triggering a plutonium bomb before the explosion of the hydrogen bomb. But, in the case of fusion reactor, which lasts for a long time, a continuous high neutron flux is required and there is no question of triggering a plutonium bomb, as this would destroy the whole installation. So the above reactions cannot build a self-sustaining chain reaction. The probability for the two reactions to take place simultaneously is very small. The above two reactions, which exist only for a short duration, are therefore more suitable for triggering off a hydrogen bomb rather than a fusion reactor. So, lithium also is ruled out as a fuel for thermonuclear power. It appears that fusion of deuterium and deuterium (d-d reaction) is the best reaction for thermonuclear power taking into account both economics and nuclear physics, and availability of fuel. Deuterium is abundantly available in nature. The d-d reactions can take place as follows



The ratio of the neutron-to-proton reactions is about 0.94. An average value of about 3.5 MeV is released from each reaction. Any tritium that is produced in these reactions can combine with deuterium to give helium (4) as already mentioned above. It can be seen that the above thermonuclear reactions are a source of neutrons too. A thermonuclear reactor can therefore be used not only for the production of power, but also for production of Pu^{239} or U^{233} by surrounding the fusion reactor with a blanket of natural uranium (238) or thorium (232). In fact, it may prove more profitable to use a thermonuclear reactor solely for the production of plutonium rather than attempting to get electric power.

Thermonuclear power

Certain very difficult and restrictive conditions must be satisfied in order to obtain controlled thermonuclear power from a fusion reactor: (1) Fusion must take place as rapidly as possible; (2) There must be some way of starting the nuclear fusion chain reaction and this cannot be by triggering a plutonium bomb; (3) The energy output must be more than the energy input. In fact, some thermonuclear reactors have been built, but the energy input is much more than the output; and (4) energy losses must be reduced to a minimum. At such a high temperature as 10^8 degrees Kelvin, which is required for fusion to take place, the atoms are completely stripped of their electrons and act only as assembly of nuclei and electrons, i.e., a plasma of positive and negative ions with great velocities, which is often called the fourth state of matter exists. The containment of this plasma and maintenance of its very high temperature are the two important aspects of thermonuclear power generation. At high temperatures the ions having tremendous velocities generate currents of the order of millions of amperes. These high currents generate very strong magnetic fields which raise the temperature of the reacting gases and which encircle the ion paths. The field exerts an inward force on the ions and constricts or confines them to very narrow regions and works as a "magnetic bottle". This bottle is not made up of any material substance. The interaction of magnetic lines of force with the charged particles confines the plasma to very narrow regions. This is known as self-confinement of plasma or the "Pinch Effect". No material container can contain the plasma, because all materials vapourise at the necessary high temperatures. This bottle is therefore also known as 'container of no material'. The self-confinement of the plasma or the constriction of the plasma to very narrow regions raises the local temperature, resulting in consequent

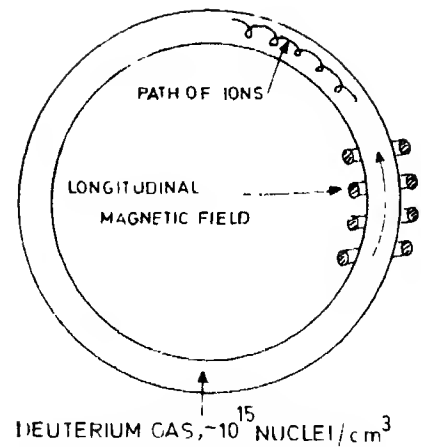


Fig. 2. Possible thermonuclear reactor

heating of the plasma. The temperature of the gases goes on increasing until fusion of the nuclei takes place. Complete ionisation of the gases at low temperatures and pressures is expected to give better results. The pinch effect therefore serves not only to confine plasma, but also to heat it to the desired temperatures.

An important aspect of the working of a thermonuclear reactor is the loss of energy by radiation. This loss varies as the fourth power of absolute temperature, according to Stephan-Boltzman's law. It is estimated that this loss may be about 10^{21} watts/cm². Such a terrible loss of energy due to radiation is undesirable, as there may not be energy output from the system. There is also appreciable loss of energy due to a phenomenon called "bremsstrahlung", which is the loss of energy due to acceleration of the charged particles. A charged particle loses energy by radiation, when it is accelerated. The positive and negative ions are accelerated due to the electric field created by the other ions and electrons. However, it was soon found that there is no thermal equilibrium and that this radiant energy is not really lost, but is reabsorbed by the plasma, raising the temperature. Thus confinement of the plasma and rise of the temperature are provided by the magnetic field of the plasma itself. Bremsstrahlung losses actually become significant at temperatures

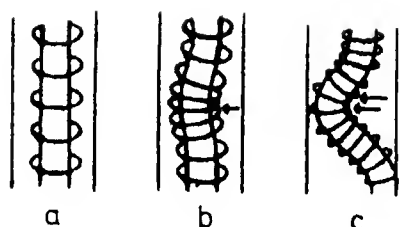


Fig. 3. Development of kink instability

more than 10^9 degrees Kelvin. At the fusion temperatures, this loss may not be appreciable.

Impurities play an important role in the working of the fusion reactor. They are a source of great energy loss, which is proportional to the square of atomic number and also to the square of the density of the electronic cloud. Care must be taken that impurities of high atomic number do not enter the system. For this reason, the vacuum must be of a very high order, of the order of 10^{-10} mm of Hg. There should not be any leakage of impurities from outside into the system. Even an impurity level of 1 in 10^6 causes a tremendous loss of energy. At room temperature, before the fusion reactor starts working, the pressure of the reacting gases must be very low to achieve control of the fusion reactor. As the reactor starts working, the temperature and pressure will be multiplied. The density of the nuclei at these temperatures of the order of 10^8 degrees K is only about $10^{15}/\text{cm}^3$. The pressure of the reacting gases is about 5×10^6 atmosphere. The ions have great velocities under these conditions and they generate currents of very high magnitude. The plasma must be confined by some kind of magnetic field which may be its own field. Operation of a thermonuclear reactor at temperatures greater than 10^9 degrees K provides sufficient energy output if there are no losses other than bremsstrahlung. Fig. 1 gives the variation of energy loss by bremsstrahlung and energy production by thermonuclear reactions with absolute temperature in the case of deuterium gas. It may be seen from the figure that, while

bremsstrahlung loss increases with temperature, it is comparatively less than energy produced due to fusion at higher temperatures and more than that produced at lower temperatures. At about 10^9 degrees K, both are nearly equal. Similarly, in the case of Deuterium-Tritium fusion reactions, the power generated increases much more rapidly than the power radiated above 7×10^7 degrees K. Below about 7×10^7 degrees K, the power radiated is much more than the power generated. At such high temperatures the ions have high velocities and they must be confined by a longitudinal magnetic field (the so-called magnetic bottle). The ions will then spiral out, moving slowly in the direction of the field, and so cannot escape. The loss of ions can therefore be minimised. A possible thermonuclear reactor can be like the one shown in Fig. 2.

While thermonuclear power seems to be very profitable and attractive, confinement of plasma and attainment of high temperatures are very difficult experimental hurdles. The stability of the plasma is a serious problem as plasma oscillations set in. Even though pinch effect provides a way for self-confinement of plasma, it was soon found out that there are many instabilities in the pinch. Elimination of impurities is a serious problem. The whole reaction may be quenched if the plasma strikes any cool wall or any other material.

Pinch instability. It was found that pinch effect is not a stable phenomenon. As the lines of force always remain in a plane perpendicular to the direction of current flow, a small kink developed in the discharge column would cause the magnetic lines of force to crowd more closely on the concave side of the kink and spread apart on the convex side. The phenomenon is shown schematically in Fig. 3. Fig. 3 (a) shows the linear pinch, confined to the centre of the tube, before the onset of instability, encircled by magnetic force lines; Fig. 3(b) shows pinch instability. A small

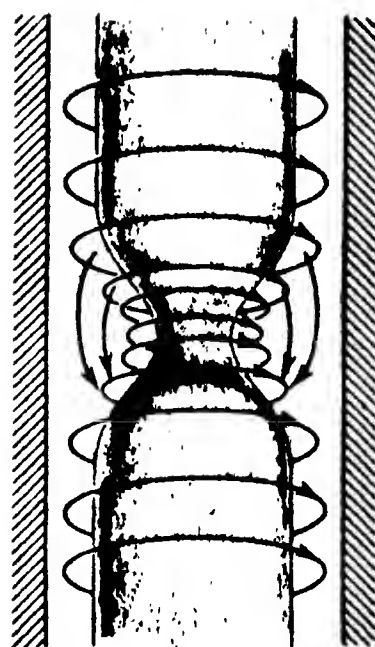


Fig. 4. Sausage or constriction instability

kink develops in the plasma column. Further development of the kink is shown in Fig. 3(c). This bunching of the magnetic force lines would create a net magnetic force on the concave side of kink and would cause the deviation to grow in magnitude. Within a few microseconds, the discharge would be thrown against the container and be cooled instantly, while the container vapourises and the plasma is polluted. Stabilisation of the pinch was a serious problem, which attracted the attention of many workers, including some Russians in the field. Shock or a sudden heating of the pinch was tried by applying very high voltage gradients for generating millions of amperes of current in an attempt to raise the temperature to thermonuclear temperatures before pinch instability sets in. Some neutrons were detected during this process and gave hopes of the commencement of fusion reactions. But they were soon proved to be "false neutrons", that they were not of thermonuclear origin. They were found to be the result of another type of instability known as "Sausage instability" (Fig. 4). The region of Sausage instability has much smaller

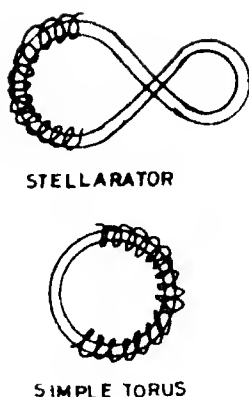


Fig. 5

diameters than the other portions of the plasma column. Very high voltage gradients exist in this region and particles acquire very high axial velocities due to the very high circular magnetic force lines. The 'hotter' particles collide with the 'cooler' particles, with the release of fast neutrons, even in the absence of fusion. Magnetic lines of force crowd in the region of Sausage instability just as they do in the case of kink instability. Various other methods of stabilising the pinch have been tried and are still under investigation. So stabilising the pinch and raising its temperature have become major problems of thermonuclear research, providing greater information about the behaviour of ionised gases, measurement of high temperatures and various aspects of plasma physics and diagnostics.

The stellarator. This thermonuclear machine has been developed by Spitzer of Princeton University (USA) while working on the production and control of high temperature plasmas. It was developed from a Torus shaped tube, which was found inadequate to contain high temperature plasma. The homogeneous nature of the magnetic field produced in a simple torus leads to instability of the plasma and the discharge may hit the walls. If the simple torus is bent into the form ∞ , it is found that the instabilities of the discharge are removed to a great extent. Current coils are wound around the tube and a magnetic field is produced along the

axis of the tube. This field together with the field generated by the plasma itself constricts the plasma to a narrow region in the tube. Fig. 5 shows the torus and Stellarator, in principle. An improved form of the Stellarator which could generate temperature of 2×10^8 degrees K, could be built at a cost of 2×10^8 to give 5×10^9 watts of electrical energy. However, doubts were later on expressed about stability of the pinch even in the Stellarator.

The magnetic mirror. This is another thermonuclear machine. It contains a straight tube unlike the Stellarator or torus. The fusion fuel is injected into the centre of the tube and heated up to reaction temperatures. If the plasma does not strike the walls or escape from the sides, we have a practical fusion reactor. This idea was first conceived by H.F. York of the University of California USA and received the support of other scientists. York was not satisfied with Stellarator. A specific magnetic field configuration in the magnetic mirror machine keeps the plasma trapped inside the tube, without touching the walls and the ions are reflected back towards the centre when they reach the ends of the tube. It is therefore called a "magnetic mirror or reflector". Fig. 6(a) and (b) gives the principles of the magnetic mirror. Very high fields generated by the mirror producing coils at the ends of the tube act as reflectors for charged particles. Injection of fuel into the cylinder under proper conditions was the most difficult problem. It must have a specific density. Heating it to fusion temperatures, confining it to the central portion of the tube, prevention of instabilities are all major problems.

Various other thermonuclear machines have been tried in an effort to harness fusion power e.g., various versions of the Stellarator and magnetic mirror, the calutron, Oak Ridge DCX machine, Kolb machine, etc. In the Kolb machine a current of about 1.5×10^6 amperes is expected

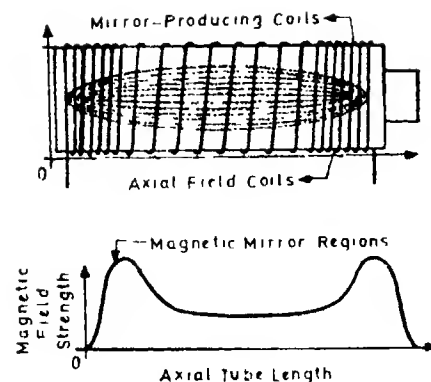


Fig. 6. Magnetic mirror machine

to be discharged in about 15 microseconds, generating magnetic fields of about 5×10^5 gauss. The Scylla devices were some modifications of the magnetic mirror. On the whole, it was felt that the magnetic mirror is better than Stellarator.

The search for thermonuclear power continues. In 1958 temperatures of about 10^6 degrees K were obtained in the laboratory. One year later, 20×10^6 degrees K was obtained. A successful fusion reactor may not be very far away. Current thermonuclear research is going on mostly in USA, USSR and to a small extent in UK.

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AMMONIA is a common metabolic intermediate in all organisms and a rich constituent of the natural environment. But it is acutely toxic, even in moderate concentrations, to all forms of life. It is for this reason that ammonia is often regarded as a physiological "waste" of nitrogen metabolism. But no waste is strictly speaking a total waste. Many of the industrial effluents, which otherwise are looked upon as pollutants of water, soil and air, may be recovered and reutilised as highly useful products. Similarly, while some metabolic byproducts of our body are excreted, some others may be recycled as essential metabolic intermediates. In general, the excess of a metabolic waste product is eliminated from a living system when it poses a toxic threat at specific concentrations and when it cannot be detoxified and utilized properly by the system. Thus substances excreted at a particular concentration and time may prove to be utilisable at another concentration at a different time. Ammonia serves as an example of an organismal as well as an industrial waste, which may prove to be quite useful and utilisable in certain physiological and environmental situations.

Sources of ammonia in the environment (see Fig. 1)

Ammonia was presumably present in abundance in the primeval atmosphere of our planet. Its present environment is also rich in ammonia derived from multiple sources.

A minor amount of atmospheric nitrogen can be fixed non-biologically through electrical discharges, when oxides of nitrogen formed are carried to the earth by rains. Biological fixation of molecular nitrogen from atmospheric air is caused by many soil organisms. These are aerobic bacteria (*Azotobacter* sp., *Pseudomonas* sp. and *Bacillus polymyxa*) and streptomycetes,

AMMONIA— A NUTRIENT AND TOXICANT

NARENDRA PRASAD DAS ASIT BARAN DAS

Notwithstanding its constant production as an intermediate of nitrogen metabolism in cell, ammonia is a severe toxicant even in moderate concentration for any organism. Enigmatically, however, the chief inorganic form of nitrogenous nutrient for many forms of life is ammonia

anaerobic bacteria (*Clostridium* sp.), blue-green algae (*Nostoc* and *Anabaena* sp.) and anaerobic photosynthetic bacteria (*Rhodospirillum*, *Rhodopseudomonas* and *Chromatium* sp.), symbiotic actinomycetes and bacteria (*Rhizobium* occurring in root nodules of legumes and even some nonleguminous plants and *Azospirillum* found in loose association with the roots of some graminaceous plants). Although details of the various steps in the chemical reactions and the inorganic and organic nitrogenous intermediates involved in this process are not yet fully understood, the ultimate products of biological nitrogen fixation and the initial inorganic nitrogenous compounds for further nitrogen assimilation (in the form of organic nitrogenous compounds) are believed to be ammonia and hydroxylamine. However, very little of ammonia remains as such in soil or surface-water. The nitrifying bacteria (*Nitrobacter* and *Nitrosomonas*) oxidise the reduced nitrogen (ammonia) into nitrites and nitrates, and unless these nitrogen compounds are utilised by soil microbes and plants for nitrogen assimilation, gaseous nitrogen is returned to the atmospheric air by the activities of denitrifying bacteria (*Thiobacillus* sp., *Bacillus licheniformis*, *Pseudomonas aeruginosa*,

Chromobacter sp.).

Ammonia is released from dead animals and plants by activities of organisms causing decay, which comprise chiefly a variety of fungi and a few bacteria and actinomycetes.

Ammonia is formed in the cell as an intermediary in nitrogen metabolism (Fig. 2). Because of its acute toxicity, ammonia must be converted into less toxic molecules like an amino acid, glutamine, urea etc., or must be excreted as rapidly as it is formed. Ammonia is apparently fully utilized in a plant body in different metabolic pathways. Most aquatic animals excrete excess of ammonia as chief nitrogenous "waste" product. Such animals are termed "ammonotelic". The best example from the vertebrates is the bony fish (teleosts). Although "ureotelic" animals (many invertebrates, amphibians and mammals) and "uricotelic" animals (insects, reptiles and birds) channelize excretory nitrogen into urea and uric acid respectively, a certain amount of free ammonia is also excreted by them. Urea in an aquatic environment can be hydrolysed into ammonia, particularly by the catalytic activity of the enzyme urease, which is widely distributed in nature (chiefly bacteria, fungi and higher plants).

Ammonia liberated from nitrogenous fertilizers (ammonium salts, urea, calcium or sodium nitrate and calcium cyanamide etc.) contaminates not only the soil of agricultural fields, but also neighbouring ponds and tanks, being washed down into them during heavy rains.

Last but not the least is the release of ammonia as a common environmental pollutant through effluents from paper mills, thermal power plants and a great variety of chemical and pharmaceutical industries.

Ammonia as a nutrient

Molecular nitrogen can hardly be utilized by plants and animals. Inorganic nitrogen of the environment is assimilated by the living system either in its reduced form as ammonia (ammonium ions) or in its oxidized form as nitrite or nitrate. However, both nitrate and nitrite ions are toxic to animals; the latter is not tolerated even by plants. Microbial organisms and higher plants can reduce nitrate to nitrite (by catalytic activity of nitrate reductase) and then reduce nitrite to ammonia (by the enzymes nitrite reductase and hydroxylamine reductase).

Organisms which do not require any organic nitrogenous nutrient are known as "autotrophs", while others requiring at least one or more of the amino acids for their optimal growth and reproduction are called "mesotrophs" or "metatrophs" respectively. Many bacteria and plants, which incorporate nitrogen from their environment in the form of ammonia, nitrate and nitrite, and the nitrogen-fixing microbes are the autotrophic organisms. The ammonium ion enters the metabolic system of these organisms by a reductive amination of a keto-acid (like α -keto glutaric acid) into the corresponding amino acid (Fig. 2). Such reactions are known to occur almost universally in all organisms. Even the pro-organisms, which appeared first on earth with a reducing atmosphere, utilized

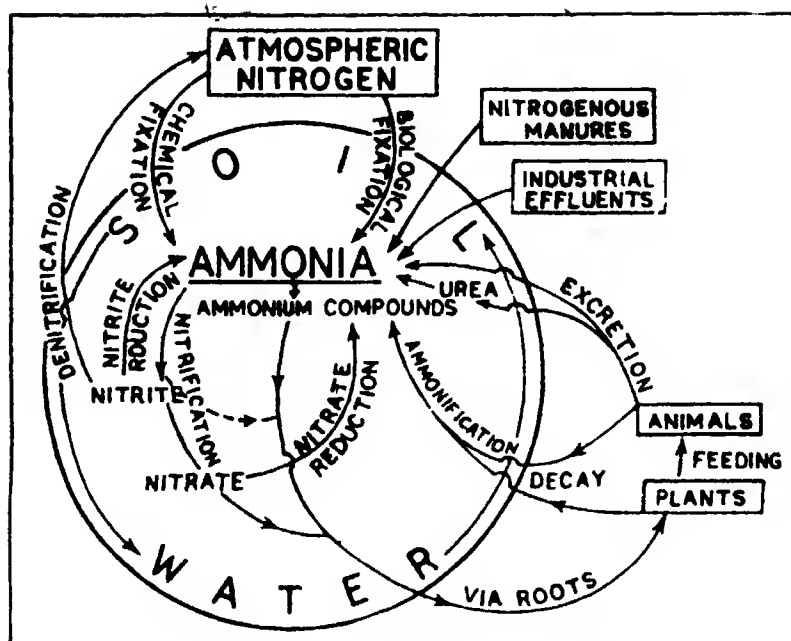


Fig. 1. Environment vis-a-vis the influx and outflux of ammonia

ammonium ions from the ammonia-rich early atmosphere of this planet, probably by reactions similar to these. Only after the evolution of green organisms with chloroplast and subsequent photosynthetic liberation of oxygen from water did nitrifying bacteria make their appearance and could obtain their required energy from oxidation of ammonium ion into nitrite and then into nitrate with the help of atmospheric molecular oxygen (Fig. 1).

Animals are "metatrophs" and they need a constant supply of several amino acids (either in the form of free amino acids or in the bound form as protein) in their food for nitrogen assimilation. Boosting of milk production in cattle by feeding these ruminants with a controlled amount of urea essentially depends on utilization of this non-protein nitrogen (NPN) for biosynthesis of amino acids by the intestinal symbiotic bacterial flora. Fingerlings of certain cat fishes, particularly those of the Indian air-breathing *Clarias batrachus* ("magur"), when given urea in diet, have shown accelerated growth and increased protein yield, as demonstrated recently (1982-1983) by scientists at the

Central Inland Fisheries Research Institute, Barrackpore, W. Bengal (personal communication). As a matter of fact, teleostean fishes, being ammonotelic vertebrates, are more tolerant to external as well as internal ammonia concentrations than the ureotelic or uricotelic animals. They offer a unique opportunity of investigating the effects of different concentrations of ambient ammonia (within tolerable limit) on their nitrogen economy. In this respect the air-breathing teleosts, found abundantly in the swampy areas of the north-eastern and southern India, deserve particular attention of ecophysiologicalists.

Recent studies in our laboratory on the snake-headed murrel, "Channa" (*Ophiocephalus punctatus*), reveal that 45 ppm-65 ppm of ammonia in the surrounding water causes a suppression of ammonia and urea excretion (thus nitrogen retention for about two weeks, when protein and free amino acid contents (even total RNA concentration) of the tissues exhibit a significant rise over their normal levels. Quite similar results have been obtained recently (1982-1983) by zoologists of Shri Venkateswara University, Tirupati

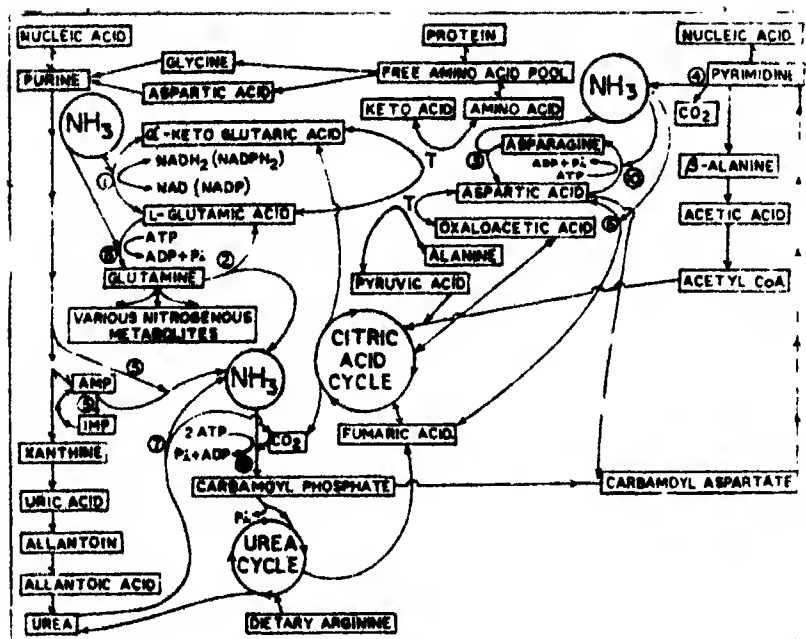


Fig. 2. Production and utilization of ammonia in cell. Reaction Nos. 1-7 are ammonia-generating and Nos. 1, 6 and 8-10 are ammonia-fixing

Andhra Pradesh, while working on the ammonia- and urea-stressed "Tilapia" (*Sarotherodon mossambicus*) (personal communication). These findings point to the potentiality of using ammonium salts or urea as a source of NPN in nursery tanks of Indian air-breathing fishes which needs to be explored. Pisciculture being an important adjunct of agriculture in India, the prospect of paddy-cum-fish culture using a common nitrogenous fertilizer (ammonia/urea) should be investigated properly.

Ammonia as a toxicant

For most organisms ammonia is regarded as a severe toxicant. Mammals (ureotelic animals) are well known for their sensitivity to ammonia. The normal human blood level of ammonia is less than 0.5 ppm. A blood concentration of approximately 50 ppm ammonia is fatal to rabbit. Even for ruminants, sufficient care must be taken in giving balanced dietary urea for promoting yield of milk, because any excess of urea could result in production of free ammonia causing toxicity. Many

non-mammalian vertebrates, invertebrates, animals and plants, however, seem to be more tolerant to ammonia. The toxicity of ammonia to aquatic organisms has been attributed to the NH_3 species (unionized ammonia). Teleostean fishes (ammonotelic animals) differ widely in their ammonia-susceptibility. For fingerlings of most catfishes, 2 ppm-3 ppm of ammonia in the surrounding water may be lethal. The concentration of ammonia in water causing 50% mortality within 24 hours is 8 ppm for trout, 10 ppm for bass and 40 ppm for goldfish. The air-breathing *Channa* (*Ophiocephalus*) is more tolerant; with 100 ppm ammonia 50% mortality occurs in 24 hours.

The reasons for sensitivity of living forms to ammonia are not completely clear, but are probably related to the overall problem of regulating the ionic environment of the cell. Being extremely soluble in water, ammonia accumulates in the cell to a high level and being sufficiently basic it raises the intracellular pH readily. The extreme alkaline condition possibly causes a meta-

bolic upset due to inhibition of enzymatic activities.

At normal physiological pH, NH_3 exists mostly in its highly reactive protonate (NH_4^+) form. Its interference in energy metabolism has been explained on the basis of a high concentration of ammonium ion 'driving' the glutamate dehydrogenase reaction towards reductive amination of oxoglutarate, retarding the rate of operation of the TCA cycle and consequently depriving the cell of energy production (Fig. 2). Besides, the ammonium cation has been postulated to interfere with many membrane functions, including active transport of cations (like K^+ and Na^+) and neuro-neuronal transmission in the brain. Experiments with injection of ammonia containing compounds in mammals indicate that brain is the most sensitive organ to this toxic molecule. The usual symptoms of ammonia intoxication in man include slurring of speech, blurring of vision, a characteristic flapping tremor and in severe cases coma leading to death. In an ammonia-stressed fish death is preceded by restlessness, overturning and drowning. Obviously brain functions are impaired in both man and fish.

Although the mechanism(s) by which ammonia upsets brain function is not completely understood, it is possible that the ammonium ion is antagonistic to neural transmission and so prevents normal operation of the citric acid cycle by constant draining of alpha-ketoglutarate in the form of glutamate and then glutamine. It has been pointed out recently (1981-'82) by Attilio Arillo of the Institute of Zoology, University of Geneva (Italy) that probably the biochemical mechanisms for ammonia toxicity in mammals and fish (teleosts) are fundamentally the same. Our observations on the murrel, *Channa*, reveal that when exposed to sublethal concentrations of ambient ammonia, the fish tends to accumulate excess ammonia in tissues like liver, kidney, gill and

muscle, "saving" blood and brain. Thus the level of ammonia in brain (and blood) probably determines the lethality of this toxicant in fish. D.K. Mukherjee and S. Bhattacharya of the toxicology laboratory of this Department have demonstrated a reversible inhibition of brain-acetylcholinesterase in *Channa* exposed to 0.05 ppm of ambient ammonia (1978).

Most organisms are endowed with some mechanism or the other to fight ammonia-toxicity. Simple aquatic organisms have no problem with ammonia-disposal, because it diffuses out freely (in unprotonated basic form) into the surrounding water and is thereby diluted to a very low concentration. Metabolic adaptations for more efficient disposal of nitrogen became necessary with the development of large size, close blood vascular system and impermeable skin. Brain is known to be the most important site of detoxification of ammonia in teleostean fish where it is trapped by glutamic acid in the form of glutamine through the catalytic activity of glutamine synthetase (Fig. 2). This glutamine carries off the excess ammonia to various parts of the body, especially to liver for further channelization of ammonia-nitrogen into various metabolites like amino acids, purine and pyrimidine bases. *Channa* exhibits an augmentation of brain glutamine synthetase activity under ammonia-stress (45 ppm-75 ppm). Aspartase and asparagine synthetase (Fig. 2), though not ubiquitously distributed, also provide additional pathways for fixation of ammonia into non-toxic metabolites. Ureogenesis through Krebs' ornithine-urea cycle does occur in hepatic mitochondria of ureotelic elasmobranch fishes (and also in the dipnoan lung-fishes subjected to

draught-stress). Although some workers have claimed to have detected the full complement of 5 enzymes of the urea cycle in liver of a few teleostean fishes, the origin of urea in them is still an enigma.

The terrestrial animals are capable of converting ammonia into less toxic products like urea and uric acid. However, all biochemical pathways for detoxification of ammonia into less toxic molecules like amino acids, glutamine or asparagine, and urea or uric acid (Fig. 2) are complex and energy-demanding (ATP-consuming). It is natural therefore that increasing concentrations of ammonia would drain the metabolic energy more and more, jeopardizing the survival of the animal. Data from this laboratory indicate that 30 ppm of ammonia in the surrounding water may be regarded as a "safe" minimal level of the toxicant for the murrel, *Channa punctatus*, causing no apparent physiological or biochemical lesion in the fish. While 45 ppm-65 ppm of ambient ammonia may be beneficial for this fish as a NPN-nutrient, exogenous ammonia above 75 ppm is definitely a harmful pollutant.

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ION IMPLANTATION TECHNIQUE AND ITS APPLICATIONS

R. K. MOHINDRA

In advanced countries, ion implantation, now in wide use commercially for improving the performance of semiconductor devices, has been shown to be beneficial in general engineering applications, notably in enhancing wear, fatigue lifetime, corrosion and oxidation resistance

ION implantation is a technique of introducing atoms of any desired element at desired sites in a solid material. Using this technique, desirable properties can be introduced in almost any material by injecting "atomic dose" of appropriate doping atoms. The technique is so powerful that a chip of silicon can be changed into a complete transmitter or receiver, a few millimeters in size. Diodes, solar cells, transistors and integrated circuits made by doping atoms using ion implantation technique have better performance than devices made by conventional process in which atoms, e.g., of boron, phosphorous, etc., are doped by thermally diffusing these into semiconductors. Ion implantation can be used with great advantage in the manufacture of coloured glass with special optical properties. Stainless steel can be toughened by implanting nitrogen ions through ion implantation.

The machine

For implantation, the selected atomic specimen is first ionised and then accelerated in an electric field to energies which usually lie in the range of a few kiloelectron-volts (KeV) to about 500 KeV in high vacuum. The accelerated ions arrive at the work piece or target with velocities greater

than that of a rifle bullet and thus penetrate the surface layers of the substrate material. Ion implantation is a low temperature phenomena unlike diffusion.

As shown in Fig. 1, the set-up used for ion implantation is essentially a simple nuclear accelerator of Cockcroft-Walton type or isotope separator but with much larger ion beam currents. Several new ion sources have been developed and it is now possible to produce currents upto 10 mA for most ion species. The second requirement is largely one of presenting the target to the ion beam in such a manner as to make effective use of the accelerated particles while avoiding undue heating of the work-piece. This is achieved by using special target of work chambers.

Very few ion implantation machine are known to be in use all over the world for handling engineering components, and several hundreds for fabrication of semiconductor devices. For semiconductor device fabrication by ion implantation, one needs ultra-high vacuum, better than 10^{-6} torr (mm of Hg pressure), and cooling arrangement for the sample or substrate placed inside target chamber. In India, some ion implantation facilities are being developed at several

places and fairly good facilities exist at Bhabha Atomic Research Centre, Trombay; Tata Institute of Fundamental Research, Bombay and Birla Institute of Science & Technology, Pilani.

Mechanism

During ion implantation there is radiation structural damage caused by incident charged ions in the material. A crystalline solid is an ordered arrangement of atoms. Any variation from this perfect ordering is treated as a defect in the crystal. Energetic ions literally knock out atoms from their equilibrium lattice sites in a crystal, thus creating lattice "vacancies". The dislodged atoms get scattered around somewhere in the solid between the occupied lattice sites. Such atoms are called "interstitials". Thus the immediate effect of incident ions is to produce vacancy-interstitial pairs known as 'Frankel pair' in a solid. The incident ion occupies the lattice or interstitial positions near the surface and modifies the near-surface material properties.

A schematic illustration of ion implantation process, showing a Gaussian sub-surface distribution of embedded atoms in the surface layers of the material sample or substrate, is shown in Fig. 2. Energised ions travelling through solid lose energy by elastic collisions with atoms of the material and by electronic ionisation and excitation. These mechanisms determine the ion range which can be calculated according to the LSS theory (1963) of J. Lindhard, M. Scharff and H.E. Schiott of Denmark. As shown in Fig. 2. (solid curve) the penetration of 100 KeV N^+ ions into steel is very shallow, being about 100 nm ($1 \text{ nm} = 10^{-9} \text{ m}$). With heavier ions the range is even less.

At temperatures of 300°C to 500°C, the vacancies and interstitials

ION IMPLANTATION SYSTEM

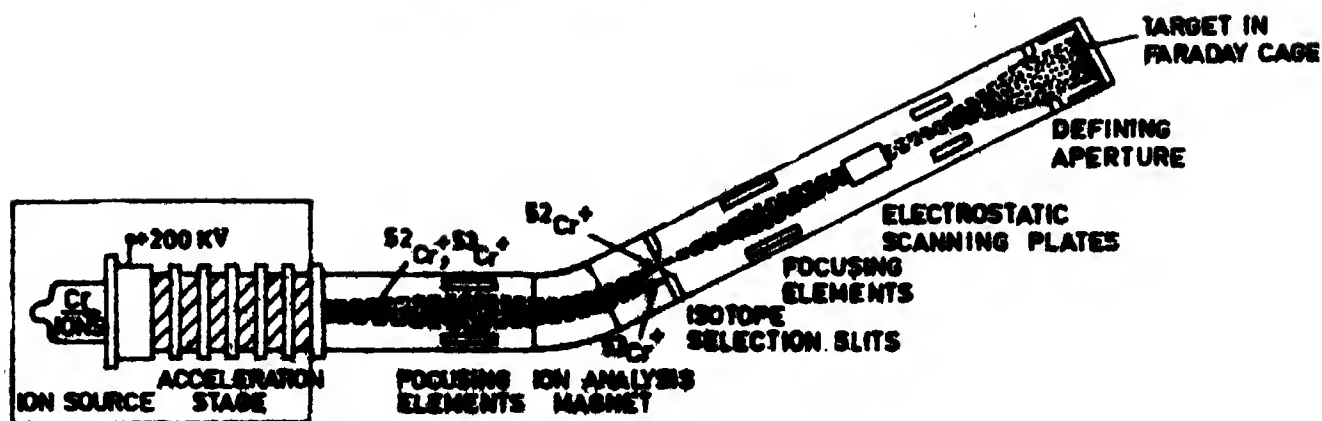


Fig. 1. A typical ion implantation system illustrated. It is basically the same as an isotope separator except that the acceleration potential is high enough to produce significant penetration of the host substrate

become quite mobile and tend to annihilate each other by recombination, thereby the damage is cured by restoring the crystalline structure of the solid. This is the principle of thermal annealing. Laser-annealing is also becoming popular.

Salient features

Some of the important material properties of solids are governed by the composition within a few micrometers (10^{-6}m) of the surface. Most semiconductor devices are constructed within this zone; wear and corrosion of metals involve near-surface properties; optical, superconducting, magnetic and electrochemical behaviour depend strongly upon surface composition and physical disorder. Control of near surface composition has been a long-standing practical requirement, achieved either by thermal diffusion or by coatings of some kind. Both processes are however critically dependent upon the defect state and cleanliness of the surface and for this reason they often lack in reproducibility. In the case of a deposited coating the interface is usually in a state of strain and frequently becomes subject to mechanical decohesion or interfacial corrosion.

Ion implantation provides a completely new and highly controllable means of altering near-surface properties of materials in a versatile manner.

Ion energies employed in the process usually lie in the range from 10 KeV-500 KeV. To minimise scattering and neutralisation of the beam a vacuum of 10^{-5} torr is desirable. The maximum concentration of implanted atoms is limited by sputtering (the kinetic ejection of atoms of the target material under ion bombardment) to a level usually between 10-50 atomic per cent. This is important in choosing an ion species for implantation; it must be effective in the concentrations which are feasible by implantation.

It has been demonstrated that the species which prove effective are frequently those which have been

employed previously as alloying constituents, or have been introduced by diffusion, e.g., chromium in steel for corrosion protection, or nitrogen in steel for wear resistance. However, since implantation is a non-equilibrium process, it is perfectly feasible to introduce species which would not form an alloy, and could not be diffused. A good example is chromium in copper: these two metals are immiscible, but an implanted Cu surface with a few per cent of Cr in it is highly resistant to oxidation or tarnishing.

Ion plating and ion nitriding

Ion plating is a coating technique in which a small proportion (0.1% to 1%) of particles to be deposited are ionised, e.g., by passage through a plasma. The process is carried out at

Table 1. Ion implantation parameters

Implanted elements	— Virtually any element from hydrogen to uranium can be implanted
Ion energies	— Normally 2 to 100 KeV. Energies upto 5 MeV may be obtained with the Van der Graaf accelerator
Implantation depths	— Vary with ion energy, ion species and host material. Ranges normally 100 angstroms to 10,000 angstroms
Range distribution	— Approximately gaussian. Choice of energies allow tailored depth distribution profiles
Concentration	— From trace amounts upto 50% or more
Host material	— Any solid material can be implanted, including metals, semiconductors, and insulators

a much higher gas pressure; typical ion energies are very low, of the order of 100 KeV, and their penetration is limited to a few nm. The purpose of ion plating is to build up a coating with a composition which is distinct from that of substrate and adhesion of coating is a matter of major importance.

In ion implantation, on the other hand, there is no possibility of forming a coating and the implanted atoms, which often are of gaseous elements, are introduced into material and act from within.

Ion nitriding is a form of gas nitriding in which a plasma is set up in a nitrogen-rich gas mixture. This serves to dissociate molecular species and atomic nitrogen can enter the metal more easily. The plasma discharge heats the work-piece and thermal diffusion transports nitrogen into the material.

Both ion plating and ion nitriding have a considerable 'throwing power' while ion implantation is a 'line-of-sight' process in which the ions arrive as a directed beam. Table 1 summarises the typical ion implantation parameters as the effects produced by ion implantation depend upon a number of factors. The main advantages of ion implantation are depicted in Table 2.

Table 2. Advantages of ion implantation

1. No sacrifice of bulk properties
2. Solid solubility limit can be exceeded
3. Alloy preparation independent of diffusion constants.
4. No coating adhesion problems since there is no interface
5. No change in sample dimensions
6. Depth concentration distribution controllable.
7. Composition may be changed without affecting grain size
8. Precise location of implanted area(s).

Table 3. Material properties influenced by ion implantation

Friction	Corrosion Resistance	Bonding
Wear	Electrochemistry	Lubrication
Hardening	Catalysis	Adhesion
Fatigue	Decorative finish	Reflectance

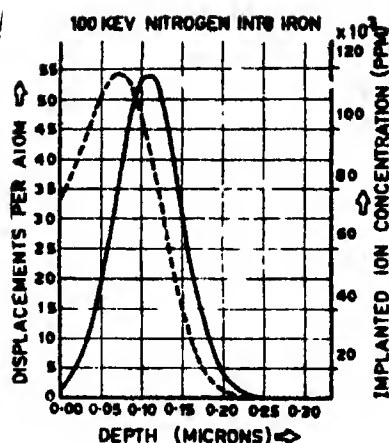


Fig. 2. Implanted nitrogen distribution (solid curve) and target atom displacements (dashed curve) produced by 10 KeV nitrogen bombardment of iron to a dose of 10^{17} ion/cm²

Applications

(1) *Semiconductor device fabrication.* The implanted atoms exert their influence within the matrix of the original material, and in this respect at least the process resembles that of diffusion. An important distinction, however is that there is no necessity of the ion to diffuse or even to dissolve in the material of the work-piece. Diffusion, furthermore, is frequently impeded by the barrier effects of surface oxides or contamination films and its rapidity is affected by the presence of dislocat-

ions and strain. Ion implantation, normally carried out at particle energies a million times greater than those created thermally, is far more predictable. Not only it is therefore a reproducible process, but also one which can be monitored continuously by a simple electrical measurement of the ion beam current.

It is for these reasons that the method is extensively used in the manufacture of semiconductor devices of all kinds. For silicon devices like p-n junctions, transistors and field effect transistors thermal diffusion of boron or phosphorous, etc. is relatively difficult to control. The adoption of ion implantation could typically lead to an increase in device yield by a factor of ten and much improved device performance.

(2) *Effects on material properties.* This work was carried out around 1976 at Atomic Energy Research Establishment, Harwell, England by G. Dearnaley and his group and has been concentrated on material properties listed in Table 3.

These are mechanical and chemical properties determined to a large extent by the composition within about 1 μ m from the surface. Wear and corrosion have been investigated in detail because of their economic value. Processes like ion implantation which can extend the life of items such as tungsten carbide tools by factors of three to ten or more are therefore of some importance.

(i) *Wear resistance.* There are two general principles for increasing the wear resistance of a material, (a) by introducing a fairly high concentration of species which will form strong interatomic bonds with the matrix and which will hamper the movement of dislocations, and (b) by introducing a solid phase lubricant or by improving the action of a fluid lubricant. It is also possible to consider adopting both approaches by a dual implantation, the first of these methods is familiar in the nitriding or carburising of ferrous

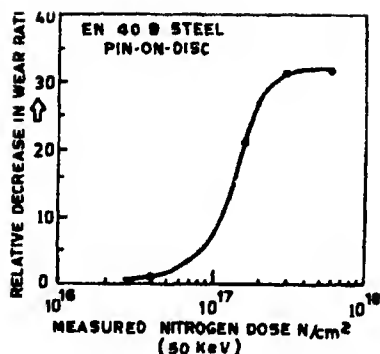


Fig. 3. The factor by which wear rate is reduced as a result of nitrogen implantation dose into nitriding steel, determined by pin-on-disc measurements

alloys and more recent process of boronising. Hard compounds such as nitrides and carbides are formed, in this case under equilibrium conditions at high temperatures. There is a close relationship between the hardness of a material surface and its wear resistance.

Measurements of wear resistance of ion implanted metal surfaces were first made by N.E.W. Hartley in 1978 at A.E.R.E. Harwell, England. A loaded pin wears against an ion implanted disc and the wear rate is measured as shown in Fig. 3.

(ii) *Friction.* The first experiment on changes in the coefficient of friction brought about by ion implantation were carried out by Hartley in 1976. Most of the tests were performed using chrome carbon bearing steel and the implanted ions of soft metals such as Pb^+ , Sn^+ , Ag^+ , and In^+ . Ions of Mo^+ , S^+ in the ratio 1 : 2 were used with the aim of forming MoS_2 which is a solid lubricant. Doses introduced were generally around 3×10^{16} ions/cm².

All the ions, with the exception of Kr^+ produced significant change in friction. This indicates that radiation damage or ion bombardment alone is not responsible for the change. The effect is controlled by change in composition. The largest reduction in friction (60%) was achieved with Sn^+ ions. It was interesting that a mixture of Mo^+ and $2S^+$, gave, an

appreciably lower friction coefficient than either of the constituents alone, although there was no direct evidence that MoS_2 was formed. Scanning electron microscopy revealed the nature of stick-slip adhesion in Pb^+ implanted steel.

(iii) *Fatigue-life improvement.*

The effect of 30 keV nitrogen-ion implantation on fatigue lifetime of steel has been investigated by S.Lo. Russo and coworkers in Italy 1980. The implants enhanced the fatigue lifetime for nitrogen doses between 10^{17} and 2×10^{17} ions cm². Their

results also suggest that implantation current density can have an important role in the thermal diffusion of implanted ions. The 30 KeV nitrogen implants were performed without mass analysis i.e., the implantation beam consisted of an admixture of N^+ and N_2^+ ions. Before the implants, the samples were electro-chemically polished.

(iv) *Corrosion studies.* Corrosion is a significant factor in USA. Recently it has been estimated that at the US Naval-Air Facilities, the annual cost for replacement of

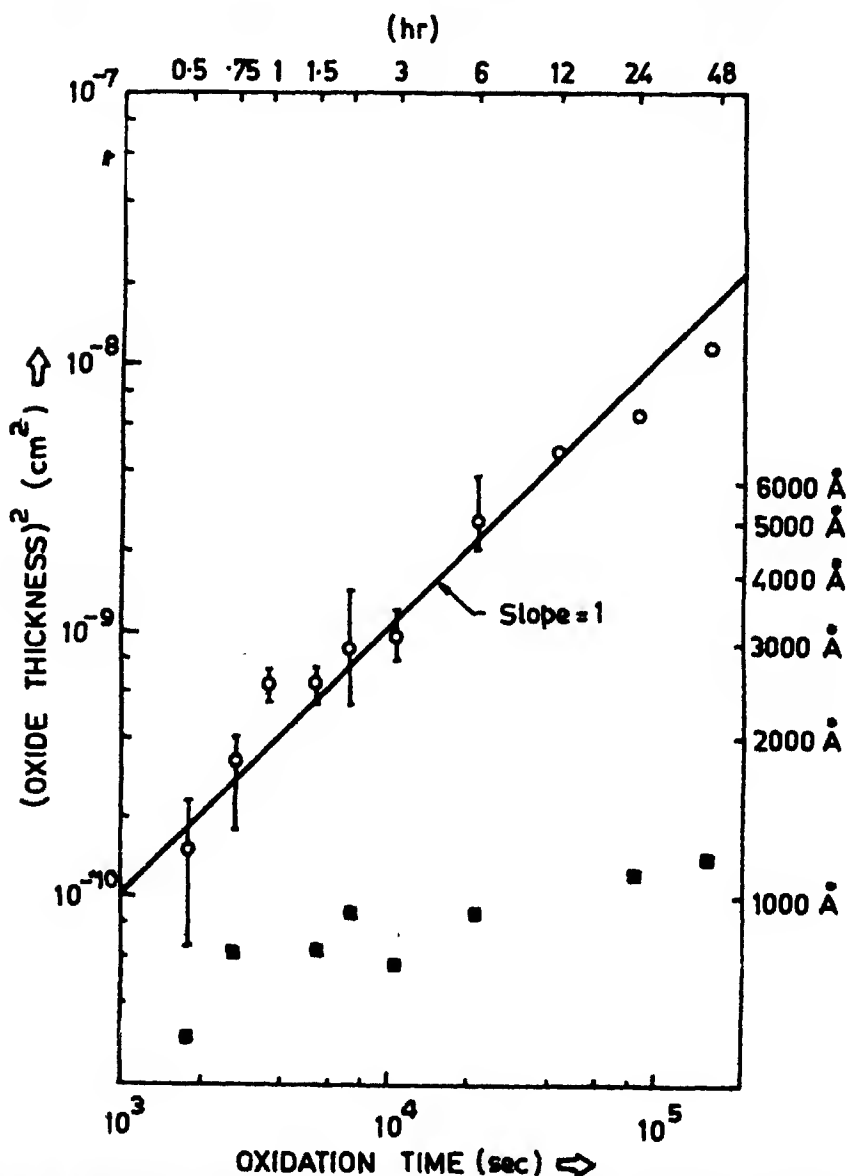


Fig. 4. Relationship between thickness of oxide layer formed on titanium and time in air at 600°C for unimplanted titanium (open circles) and barium-implanted titanium (close squares)

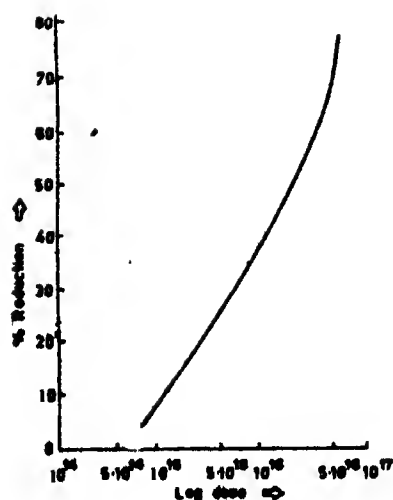


Fig. 5. The effect of calcium implantation on the oxidation of titanium in oxygen at 600 °C, as a function of ion dose

turbojet engine bearings damaged by corrosion alone is estimated to exceed \$ 2 million.

Corrosion-related implantation work can be grouped under the following arbitrarily selected categories: (a) Atmospheric corrosion or degradation; (b) High temperature oxidation; and (c) Aqueous corrosion.

Corrosion science is being extensively studied by using ion beams by V. Ashworth and others at Corrosion and Protection Centre, Manchester, U.K.

(a) *Atmospheric corrosion.* The inhibition of atmospheric degradation of metals following ion bombardment constitutes one of the oldest phenomena accompanying implantation. It has been reported that copper beam line components removed from isotope separators retain a shining appearance in only those areas which had been exposed to the beam. More recently, a number of workers have observed an inhibition of atmospheric tarnishing following

ion implantation, but more work is needed to understand this phenomenon.

(b) *High-temperature oxidation.* Ion implantation effects related to high temperature oxidation are better understood than those involving atmospheric corrosion. G. Dearnaley and coworkers at Harwell (1978) have been active researchers in this field. Their early work showed that oxidation of chromium-rich stainless steels was significantly reduced by implantation of yttrium or rare earth ions, and the implanted ions stayed close to the interface and reduced oxide spalling. One hypothesis for the increased protection was the formation of impermeable barriers of perovskite structures such as YCrO_3 or LaCrO_3 .

Studies of Ti oxidation have shown that those implanted species which formed perovskite structures (e.g., Ba, Ca, Eu) were most effective in inhibiting thermal oxidation as shown in Figs 4 and 5. There is evidence that several implanted species diffuse deep into the material at temperatures below 800°C (presumably along defect networks) and can still inhibit oxidation on both sides of an implanted foil (50 μm thick).

The oxidation resistance of FeCrAlY alloy can be improved by implantation. A stainless-type copper has been produced by implanting Al, Ti or Cr (a normally insoluble element) into copper. This suggests possible use of these ions for corrosion-free electrical contacts.

(c) *Aqueous corrosion.* The implantation of Cr into commercial steel by J.K. Hirvonen and coworkers at Naval Research Lab., Washington, U.S.A. (1978) demonstrated the potential advantage of implantation for improving the (surface) corrosion of a material without impairing its bulk properties. The advantage that implantation is a low temperature process appears to be important for its potential application to situations where elevated temperatures may produce undesir-

able bulk property changes. However, it is too early to assess the utility of ion implantations approach for controlling aqueous corrosion.

Ion implantation is today established as a powerful method of controlling the near-surface composition and properties not only of semiconductors, but also of a growing variety of other materials. New developments in accelerators and ion source design are increasing the range of possible applications. For the future, it provides a most interesting area of interdisciplinary research.

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CHARACTERISATION OF SOLID CATALYSTS

M.R. BALASUBRAMANIAN

A knowledge of the physicochemical properties of a solid catalyst is vital for assessing its suitability for a particular application

CATALYSTS are the vaulting poles used by reactants for jumping over the energy barrier that separates them from the products. When the catalyst belongs to a phase (usually solid) different from that of the reactants and products (usually gas or vapour), the catalysis is known as heterogeneous catalysis. As most of the heterogeneous catalysts are solids, their solid state behaviour may be expected to influence the catalytic activity. In this context two facets of the nature of the solid state deserve consideration: arrangement of atoms, ions or molecules in solids, and availability of orbitals or electrons in solids for interaction with gases. The former is called the geometric factor and the latter the electronic factor.

Geometric factor

Solids may be made up of molecules, ions or metal atoms. These building blocks are arranged in a regular repetitive pattern in all crystalline solids. The dependence of catalytic activity on crystal structure was first observed by A.T. Gwathmey, an American scientist, who reported in 1958 that the rate of decomposition of CO over nickel catalyst was different for different crystal planes of the metal. Catalytic reactions, whose rates depend on the

nature of the crystal planes in the catalyst exposed to the reactants, are known as structure-sensitive reaction. Another illuminating fact suggesting a relationship between crystal features and catalysis is the enhanced catalytic reactivity observed at dislocations (linear imperfections in crystals).

Electronic factor

The three types of solids mentioned earlier differ in their ability to give up or accept electrons. Molecular solids (with very few exceptions such as graphite) lack this ability. Ionic solids possess this ability if they are doped or defective. Metals can only give up but cannot accept electrons. The dependence of catalytic activity on this electronic factor has been demonstrated in both metals and semiconducting oxides through the phenomenon of chemisorption. Chemisorption occurs when a solid (metallic or otherwise) donates electrons to or accepts electrons from gas molecules resting on it. If such gas molecules are converted into cations, the process is known as cationic chemisorption. If the gas molecules are converted into anions, the process goes by the name of anionic chemisorption. Chemisorption is a pre-requisite for heterogeneous catalysis.

The contributions of the two factors and of an interplay of both can be assessed only if, in addition to the chemistry of the reacting gases, the physicochemical characteristics of the solid catalysts are definitely known. Properties included in this characterisation fall into one of the following types :

1. Crystal Structure or Structural Properties (such as lattice type, lattice vacancies, etc.)
2. Thermal Properties (such as polymorphic changes, thermally induced lattice distortions, etc.)
3. Electrical Properties (such as electrical conductivity, type of semi-conduction, etc.)
4. Magnetic Properties (such as magnetic susceptibility)
5. Optical Properties (such as infra-red and ultra-violet spectra)
6. Chemical Properties (such as oxidation state)
7. Surface Properties (such as surface acidity, surface area, etc.)

Structural properties

A knowledge of the crystal structure of the catalyst is vital for the successful interpretation of the observed level of activity of the catalyst for a given reaction. Some types of lattices (arrangements of atoms in a crystal) are associated with high catalytic activity, e.g., oxides with the crystal structure of spinel (magnesium aluminate) are proven catalysts. Lattice type also governs the type of reaction catalysed, e.g., CaO (having the NaCl type lattice) is a dehydrogenation catalyst, whilst Cr_2O_3 (having the so-called corundum type lattice) is a good dehydration catalyst. Crystal structure can be determined through X-ray diffraction. Crystal structure and density (high-precision methods are available for density determination) together reveal the presence of lattice defects such as vacancies or extra atoms (interstitials).

Thermal properties

Some crystals which are tetragonal (cube pulled along one direction) at room temperature become cubic on heating. The temperature at which this phase transition occurs is important for catalysis, because the two phases are usually different in activity and the activity reaches a maximum at the transition temperature. In ionic crystals containing two cations, a regular arrangement of the two cations may be transformed into a random arrangement at a particular temperature. This is known as order-disorder transformation. Ordered and disordered phases invariably have different catalytic activities. The above phenomena can be studied through differential thermal analysis.

Electrical properties

Solids conduct electricity through the agency of electrons (as in metals or n-type semiconductors such as ZnO), or holes—absence of electrons—(as in p-type semiconductors such as Cu_2O). Whether a solid is n-type or p-type can be found out by measuring what is known as the Seebeck co-efficient and its algebraic sign. A more pertinent method involves flooding the catalyst surface with oxygen and then observing the concomitant change in conductivity. Oxygen can only accept electrons. When electrons flow from n-type semiconductor to oxygen, concentration of charge-carriers decreases and hence the conductivity of the n-type semiconductor also decreases. When electrons flow from p-type semiconductor to oxygen, concentration of holes which are the charge-carriers in p-type semiconductors, increases and hence the conductivity also increases. For measurement of electrical conductivity, the powdered and pelletised catalyst sample is sintered and its resistance measured across the pellet of known dimensions using a vacuum tube voltmeter.

Magnetic properties

Electronic factors depend pri-

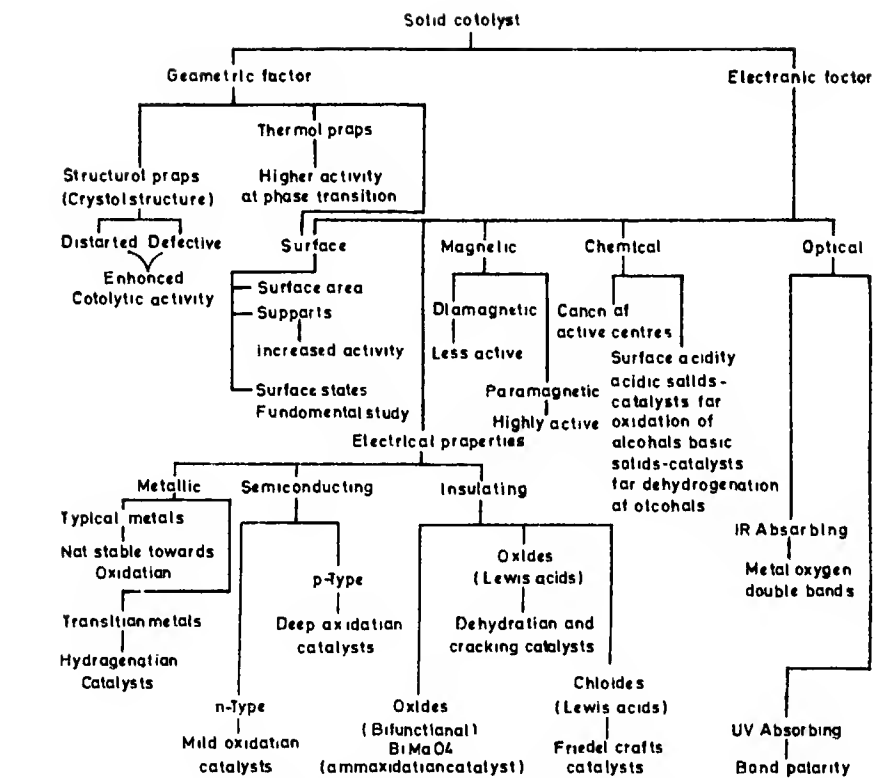


Fig. 1. Properties of solids relevant to catalytic studies

marily on the presence of unpaired electrons in the catalyst molecule. Determination of magnetic susceptibility helps in the detection of unpaired electrons. The reason is not far to seek: molecules containing unpaired electrons are paramagnetic (possess a magnetic susceptibility) and those devoid of unpaired electrons are diamagnetic (have zero magnetic susceptibility). Magnetic susceptibility can be measured through weighing a mass of the sample in the absence of magnetic field followed by weighing in the presence of a magnetic field. If the sample weighs more in the presence of a magnetic field than in its absence, the sample is paramagnetic. If the paramagnetic centres are very few and widespread, they can be detected through electron spin resonance spectroscopy.

Optical properties

By optical properties is meant the effect of electromagnetic radiation on the solid. Part or whole of the radi-

ation energy is absorbed in a particular wavelength region of the spectrum. From the wavelength (or wave number) and intensity of the transmitted beam the nature of the molecules can be unravelled. Depending on the wavelength of the radiation used, the effects prevail. Infra-red, the long wavelength region affects vibration of the chemical bonds. Ultra-violet, the short wavelength region, causes transition of electrons to higher energy levels. Thus the type of bonds and the type of orbitals can be gauged from IR and UV spectra respectively. More useful information can be obtained by recording the spectra of the adsorbed species on the catalyst surface.

Chemical properties

It may be recalled that semiconductors are good catalysts. Most of them are non-stoichiometric, i.e. their formulae differ slightly from the integral ratios dictated by Dalton's theory. For instance, there are several different phases between the compo-

Table 1

Sl. No	Property for study	Method
1.	Crystal Structure	X-ray diffraction
2.	Crystal Defects and Non-stoichiometry	X-ray diffraction, density determination and chemical analysis
3.	Thermal Distortion	Differential Thermal Analysis (Derivatograph)
4.	Electrical Conductivity, Type of semi-conduction	Conductivity set-up, Seebeck Co-efficient.
5.	Magnetic Susceptibility number of unpaired spins	Guoy Balance ESR
6.	Bond type	IR Spectra
	Orbital type	UV Spectra
7.	Surface Area	BET set-up/Sorptometer
	Surface Composition	XPS, LEED
	Surface Acidity	IR of adsorbed species

sitions V_2O_3 and V_2O_5 . One such phase, V_6O_{13} , is known to possess excellent catalytic properties. These phases can be detected and estimated only if X-ray analysis and a comprehensive chemical analysis are combined.

Surface properties

A piece of iron does not catch fire, but very fine powder of iron is pyrophoric. This is so because for a given mass of material the surface area is larger in the powdered sample. Being a surface phenomenon, the heterogeneous catalysis naturally depends on the extent of the surface. Surface area of a catalyst can be increased by carefully avoiding the conditions (such as high temperature) that lead to sintering during the preparation of the catalyst. A better and more easily practicable technique is to disperse the catalyst on the surface of an inert

support such that each crystallite of the catalyst can offer its whole surface for catalysis.

Surfaces may be acidic or basic. Nature of the acidity or basicity and the population of the acidic or basic centres on a solid catalyst control its catalytic behaviour. Several methods exist for the determination of surface acidity and basicity. Neutralisation by an acid (or a base, as the case may be) in a non-aqueous solvent and the spectral method are two such methods.

Techniques used for measuring the above properties are given in Table 1. Properties which frequently need investigation in the context of catalysis are mentioned in Fig. 1. Types of reactions which are broadly expected to be catalysed by a solid possessing a given property are also indicated (Fig. 1). When, however, the effects of two such properties are

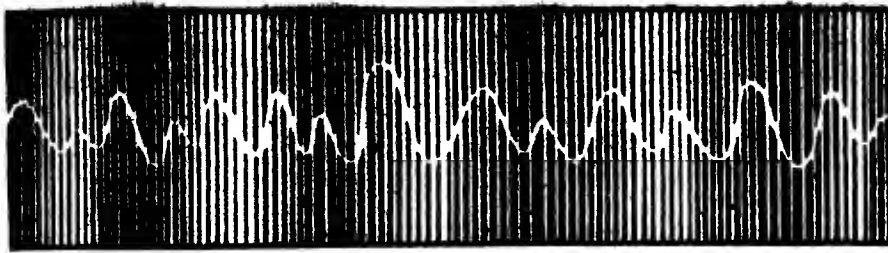
diametrically opposed to each other, explanation of the observed catalytic behaviour becomes difficult.

Modern tools for surface studies

Though the above methods of characterisation suffice in most of the circumstances met with in practical situations, they are not adequate for gaining an insight into the nature of the catalytic surface. Surface of a solid differs from the bulk of it in regard to energy, bonding and chemistry. Sophisticated methods (low energy electron diffraction, X-ray photoelectron spectroscopy, etc.) are at hand for the fundamental study of surfaces of solids. A judicious combination of the different methods leads to a good choice among catalysts for a particular reaction.

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SCIENCE SPECTRUM

And now superluminous stars

UNTIL a few decades ago, astronomers had believed that a huge star, its mass hundred times that of our special star "Sun", was not possible to form and exist in the universe. In fact, a star with a mass sixty times that of the solar mass was considered to be a rarity—only one in a billion stars. And not only that this view was simply based on astronomical observations of the night sky but it was also backed up by mathematical calculations. Only a small star was possible to form and live. But in these days of giant structures, astronomers, too, have discovered some stars in the universe having a supermass, as much as thousand times the solar mass. Those stars are therefore also dazzling in brilliance! Known as "Superluminous" objects, one particular star, designated *R 136 a1*, has received considerable attention in recent times because it is in one of the nearby galaxies. Although it is still too early to say anything substantial about this object, one thing is sure that our ideas of the formation of stars are in for a change.

R 136 a1 is in the 30 Doradus Nebula, the irregular, extra-ordinarily bright and largest gaseous nebula in the neighbouring 30 or so galaxies. One can imagine how large is this nebula from the fact that whereas the so-called Great Nebula in the Orion constellation looks like a fuzzy star in the night sky to the unaided eye, 30 Doradus is of the size of the Sun or Moon in the sky, although it is

hundred times farther away than the Great Nebula. At one time, an object, designated as *R 136*, near the center of the 30 Doradus Nebula, was believed to be a massive superluminous star emitting light about 10 million times that the sun emits. If one included the invisible ultraviolet radiations, one had to multiply the above figure by fifty to get the total amount of radiations, visible and invisible, emitted by the object. On closer examination, however, the object was found to be composed of three components, *R 136a*, *R 136b* and *R 136c*, arranged in form of a comma, the brightest among them being *R 136a*.

However nothing much could be determined about *R 136a* until the International Ultraviolet Explorer (IUE) satellite was launched in 1978. The IUE satellite studied the enormous amount of invisible ultraviolet rays which are otherwise absorbed by the terrestrial atmosphere. It was then found that *R 136a* has a surface temperature of 45,000-80,000 K and is losing mass in form of a wind, called "Stellar wind", which is moving at a velocity of 3,500 km/sec. Ordinarily, a very hot star has a stellar wind moving at a velocity of 2,000 km/sec. Nevertheless, on a fluke excellent "seeing" conditions on earth and using a novel astronomical technique "Speckle spectrometry", the object *R 136a* was itself found to be consisting of four stars, of which *R 136a1* was the

brightest. Today, *R 136 a1* is considered as the "Superluminous" object, although there is still uncertainty as to whether it is a single star or a cluster of stars. If it is a single star, it is estimated to have a mass 400-1000 times the solar mass—twice as large as any previously known star.

Now there are some problems to be overcome to explain the formation of a supermassive, superluminous star because till recently the presence of such a star was ruled out. In normal course, a star or a cluster of stars is formed when a cloud of cold gas and dust collapses at one point or several points. Around the point (or points) the mass gets collected and due to gravitational forces the thermonuclear reactions occur. The proto-star thus formed begins to release heat and radiation which push away the gas and dust still continuing to fall on the star due to its gravitational pull. In due course, a balance is struck between these two opposing forces and the star assumes a stable existence. In case, the dust in the neighbourhood is above a particular limit, the star would assume a stable existence, however, with a shell of dust about it. In other words, a limit on the size of the star is enforced.

So, the formation of a supermassive star is possible only due to some exceptional circumstances. For instance, the cloud that collapses to form it had to have a very large amount of gas to begin with. It should also be at a lower temperature as compared to a normal star in the process of formation. More mass could therefore pile up before the heat and radiations generated by the star began to prevent any further accumulation. The star could also keep itself stable due to its high rotation speed and magnetic field embedded in it. Then there is also the intriguing possibility that such a supermassive star could have formed out of coalescence of a cluster of stars, just as drops coalesce to form a

bigger drop, although the formation of such rare stars in a cluster is still a debatable issue. One cannot be sure about any one of these possibility at the moment because the formation of stars is in itself a subject full of puzzles! Why not explain away the high mass and high luminosity of *R 136a 1* due to the presence of an exotic object, such as, a black hole at its center? There is no need for such an exotic object because the radiations that the superluminous star emits are of an otherwise normal star (*Scientific American*, August 1984).

The interest in *R 136a1* has sparked off due to the discovery of other similar stars in the sky. In our own galaxy, the Milky Way, the

object *NGC 3603* seems to be smaller version of *R 136a1*. In fact, astronomers have begun to think that such superluminous objects must be quite a few because massive, gaseous nebula, where they (the stars) are formed, are present in the universe. These stars have however not yet been discovered because they emit a large amount of invisible ultraviolet radiations which are absorbed in the terrestrial atmosphere and are thus lost to astronomers of earth. NASA's Space Telescope due to be launched in 1986 would enable astronomers to spot many more such stars and to study them on a much more extensive scale.

DILIP M. SALWI

Contact lens

CONTACT lenses are disc-like transparent structures made of polymeric materials and superimposed on the cornea to improve visual corrections of persons with astigmatism (a kind of eye defect). The wearer has then not to balance and bear the load of spectacles on his nose. In the beginning, glass was used exclusively for some years and lenses had to be ground and prepared for an individual's need. The introduction of a plastic corneal contact lens was a major landmark. The pioneer work of Professor Wichterle of Prague in the late 1950s with acrylic hydrogels opened up the doors of contact lens and completely revolutionized the industry. Acrylic polymers began to replace glass due to their toughness, physiologically inert nature and optical properties.

To know the mechanism of working of a contact lens one needs some understanding of the human eye (Fig.1). The eye is exquisitely sensitive and is able to adjust to the dimmest of light (less than 100 photons) as well as to brilliant sunshine within a minute without being blinded. No man-made photo-

graphic system can function under such extremes. The outer layer of spherical eye-ball serves to focus light on retina, a light sensitive tissue at the back of the eyeball as thick as a tissue paper. Incident light first passes through the transparent cornea, then through the pupil into the lens and finally hits the retina, whose "photoreceptor" cells convert light into electrical signals, which are passed on to the brain by optical nerves.

Iris is the circular muscle in front of the lens and regulates the amount of light entering the eye by acting as an adjustable shutter. Rods and cones are two types of light-sensitive cells which serve as photoreceptors of retina. Cones are colour-sensitive and work in bright light, while reverse is the case with rods. Aqueous and vitreous humour (gel) are two different liquids which maintain the shape of eye. A contact lens may be considered as an extension of cornea and accompanies it in all the movements of the eye-ball. The design and fitting of a contact lens are important for the comfort of the patient. Also, a good contact lens can be easily removed and inserted. Among the

Outer portions of eye focus light on retina

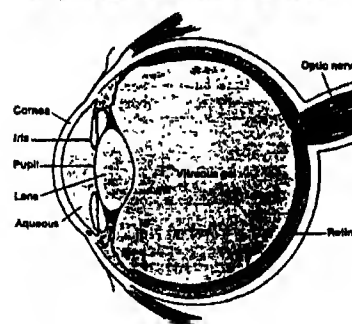


Fig. 1. The human eye

essential requirements, optical transparency of the material is of prime importance. It is relatively easy to find a material which transmits approximately 90% of the light in the visible range of the eye (400-750 nm). Also, a material whose refractive index is close to that of cornea is not hard to find.

There are also many other essential requirements of a contact lens. In the first place, it is necessary for the cornea, which consumes oxygen directly from the atmosphere, to respire in a substantially undisturbed manner to carry out the metabolic processes of living cells. Oxygen permeability is therefore essential in developing new polymers for contact lenses. It however varies with the chemical structure and morphology of the polymer. Secondly, the tear must wet the lens sufficiently so as to maintain a continuous tear film on the lens. The tears must flow down across the eye so that the contact lens floats on the eye providing comfort to the wearer. Thirdly, in order to maintain visual stability, the lens should be able to resist the deforming force of the eyelid during blinking.

The surface properties of the material must not encourage accumulation of proteinaceous debris or growth of microorganisms on the surface of the lens. Almost neutral pH and almost constant temperature of the eye are ideal conditions for the proliferation of microorganisms. Cleanliness is essential to retard bacterial growth and for the removal of deposits from the lens. Residual

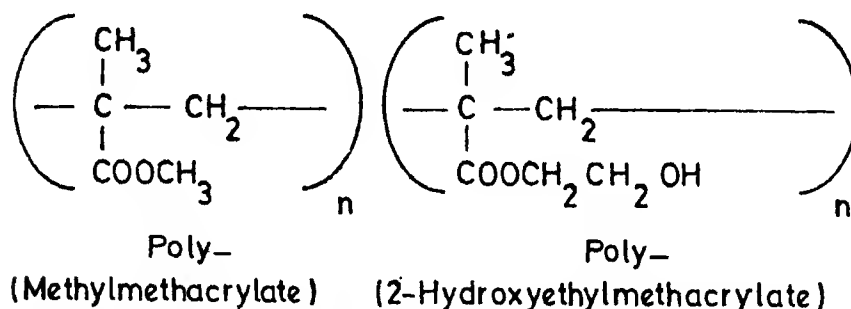


Fig. 2. Two principal polymeric materials for contact lenses

amount of cleansing agents or their breakdown products should be harmless to the eye. Also, the contact lens should be physiologically inert so as to cause no disturbance to the surrounding tissue. Even water absorption on the cornea can alter the refractive index of the lens material.

Hard and soft contact lens

Two different types of contact lenses are used: (a) Hard contact lenses are made of thermoplastic materials which are hard and hydrophobic (not wetted with water) and (b) Soft contact lenses which are made of hydrogels of polymer which are hydrophilic (wetted by water). Hard contact lenses cover a portion of the cornea, about 5 to 11 mm in diameter (the diameter of cornea is approximately 13 mm). A properly fitted lens should neither cause the wearer discomfort nor interfere with the normal functioning of the eye. Problems in achieving adequate tear flow often arise when some wearers are unable to adapt to the lens. In other cases physiological changes in the cornea, e.g., corneal swelling, are observed.

Almost all thermoplastics are tough and permeable to oxygen and so to find a hard lens material is not a tedious task. Poly (methylmethacrylate), polyethylene, poly (vinyl chloride) and other halogenated vinyl polymers, polystyrene are the materials proposed for the lens. As yet none have proved acceptable in the sense that they are unable to

promote the flow of tear fluid under the lens, a primary requirement for the physiological compatibility of the lens and the wearer.

Poly (methylmethacrylate) has however attracted much attention due to its transparency, toughness and physiological inertness. Poly (4-methyl pent-1-ene) and cellulose acetate butyrate are the polymers which possess higher oxygen permeability and are less rigid and brittle than poly (methylmethacrylate). But despite these superior qualities, the former are yet not used in common practice. Poly (methylmethacrylate) is still being used in making hard contact lenses. Researches are in progress to obtain a copolymer of methyl methacrylate with some

polymer-containing high oxygen permeability, e.g., silicones. Soft contact lenses are derived from acrylic hydrogels. Poly (2-hydroxyethylmethacrylate), which is totally compatible with human eye, is a principal polymer used for making this type of contact lenses.

Soft contact lenses are more comfortable to the wearer, cause fewer initial problems and are durable. There is also no need of removing them in the night because they have a very high oxygen permeability. The soft lens is much like a membrane with limited mobility on the eye. It is glassy and brittle when dry and becomes soft after swelling in water. It retains a significant fraction of water.

Unfortunately, with all its advantages and comfort the soft contact lens is not without shortcomings. Soft contact lens cannot, for instance, correct severe astigmatism. Hydrophilic contact lenses are nevertheless still to be developed further. As more advanced polymeric systems are developed, long-term and eventually permanent systems are envisioned.

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Photocatalytic decomposition of water for hydrogen production

THE current energy crisis has created a tremendous interest in discovering new sources of fuel to supplement our dwindling resources. Solar energy as available on the surface of the earth constitutes clean, non-polluting, abundant and relatively "free" energy source. Solar energy may be converted directly into heat, mechanical energy, electricity or fuel. Catalytic splitting of water by sunlight to produce hydrogen, recent work in this area and some of the problems that still remain are discussed here.

Stable high energy chemicals are

the best means for efficient storage of energy for long periods of time. Direct conversion of the energy of sunlight into the free energy of a chemical product is considered a permanent solution to the energy problem. Several chemical systems have been envisaged for optical-to-chemical energy conversion. Recently, studies on photoelectrochemical (PEC) cells based on semiconductors offer the unique advantage of converting optical energy into chemical energy in a single step process. It is a field of multidisciplinary activity. Water can be

dissociated by visible light by

1. Photochemical processes—using photocatalysts such as compound salts and photosynthetic dyes.
2. Photobiological processes—natural or synthetic chlorophyll, algae and bacteria.
3. Photoelectrochemical processes—using semiconductor photocatalysts such as SrTiO_3 , etc.

While the goal of an efficient and stable system for the direct solar production of fuels remains an elusive one; semiconductor based systems remain the most efficient chemical systems described so far for such a reaction.

The decomposition of compound molecules of water requires breaking of its molecular bonds. This bond can be broken by providing necessary energy by heat, electricity or light photons. The system $\text{H}_2 \xrightarrow[\text{cat}]{h\nu} \frac{1}{2}\text{O}_2 + \text{H}_2$ employs an abundant raw material (water) and produces a fuel (hydrogen) which may be readily stored and shipped. This fuel can be used to provide heat without any environmental pollution and to produce electrical power efficiently, cleanly and cheaply in a fuel cell. In addition, the hydrogen can be used as the basic raw material for producing other clean fuels and valuable chemicals from various sources such as coal and shale.

Since 1972, a tremendous explosion of information and work on this subject is seen. The solar power efficiency of most photoelectro-synthetic systems with no input of external electrical energy is generally about 1%-2%. Photo-assisted processes, where an electrical bias is applied to the PEC cell and both radiant and electrical energy are used to produce products which show higher efficiency is of less interest from a practical view point. For example: Pt/HCl-KCl-P-InP (Ru-coated); Solar-to chemical (H_2) conversion efficiency (μ) 12%.

Research until now has explored various semiconductor materials for

their possible applications in PEC's for solar energy conversion. Essential factors controlling the interfacial processes are fairly well understood. However, crucial material problems remain to be solved before realizing any practical device. The fact that nearly 50% of the theoretically possible upper limits of energy conversion efficiencies have been achieved with regard to solar-to-hydrogen indicates that further improvements are definitely possible.

Since the first light-assisted electrolysis of water using a semiconductor electrode was performed by Fujishima and Honda, many materials have been tested which can

accomplish this goal. Yet none has so far been shown to simultaneously satisfy the obvious requirements of using only visible light, long term stability operability at near neutral pHs with a practical efficiency and reasonable economics of operation. With the efforts under way in a number of academic and industrial laboratories throughout the world, semiconductor/liquid junction systems continue to show great promise as devices for solar-driven chemical reactions.

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Utilising microorganisms to harness solar energy

EVERY second the sun releases a vast amount of energy into space. The proportion of the energy reaching the surface of the earth is far greater than the energy consumption of all the countries of the world taken together during the same period. The world consumption of energy is over 56×10^{12} kWh, which is equal to the solar energy received by an area of 22,000 km^2 in a desert region. Such an area constitutes only 0.005% of the surface of the globe. The solar energy can be harnessed by indirect methods such as tidal, geothermal and wind or directly through photosynthesis. The possible uses of solar energy for domestic purposes include house water heating, desalination of sea water, drying of fruits, vegetables or fish, refrigeration, and solar powered plants and solar cells. The other direct application of solar energy is photolysis by which electricity and H_2 gas can be produced.

Biological solar energy conversion produces renewable substrates with energy which is several folds the world's energy budget. Photosynthesis itself fixes 2×10^{11} tonnes of carbon with the energy content of 3×10^{21} Joules, which is about 10

times the present world needs and 200 times the world's food energy consumption.

Paradoxically, although much attention has been given to the propagation of biomass utilisation, the crisis appears to have been provoked by the diminishing supplies of traditional fuel such as wood, dung and straw. It is estimated that these fuels comprise 90% of the total energy used in the non-OPEC developing countries.

In India it is estimated that 970 million tonnes of wet weight of dung equivalent to 170 million tonnes of dry biomass is available annually. The energy available from dung is about 1227×10^{12} BTU as against 2933×10^{12} BTU available presently through coal, oil and hydroelectric system. Another advantage of biogas is the availability of 3.04 million tonnes of N, 2.85 million tonnes of P_2O_5 and 1.9 million tonnes of K_2O as byproducts.

The advantages in the use of biogas are many. It is easy to store for use at will. It is renewable and can be obtained using technology already available with the minimal energy input. It is ecologically inexpensive and free of hazards and does not add

to atmospheric CO₂. The problems in the use of plants as biomass are competition for land use, uncertainty of supply in the initial phase and fertiliser, soil and water requirements.

Nevertheless considerable progress has been made in the use of plants to improve biomass the world over. In Brazil, for instance, extensive sugarcane cultivation is under way for conversion to alcohol by fermentation. Blended with petrol this alcohol is used to run cars. In Canada, by 2025 about 40% of transport fuel could be provided by methanol produced from biomass. In Australia, five species have been selected, namely, the eucalyptus, cassava, hibiscus, napier grass and sugarcane, as the most potential high-yielding crops for biomass production.

Presently extensive work is in progress on the use of agricultural wastes such as straw, bagasse and other cellulosic substrates not only in the cultivation of mushrooms, but also in the preparation of glucose, alcohol and single-cell protein by growing on them powerful cellulolytic cultures like *Trichoderma reesei* and *Aspergillus terreus*.

In this connection in our laboratory at Goa we have successfully converted low protein containing rice straw into highly nutritive possible cattle feed with the protein content of about 40%. Besides, the pre-treated straw has been successfully converted into glucose and single-cell protein utilising the cellulolytic fungus *Aspergillus terreus* isolated from decaying timber in the brackish waters in Bombay.

Although considerable attention has been given to the plant biomass programme, scant attention has been given to the fast-multiplying, less space-requiring and easily cultivable microorganisms. The role of microorganisms as a tool for rural processing has been established and the microbes have been deployed in the production of fuel, fibre, fertiliser, feed and food. The photosynthetic

microorganisms are the most efficient in capturing solar energy and are important in diversifying agriculture from land to water and ocean farming.

In Japan, the cultivation of marine algae has gained tremendous potential. In the marine and brackish water habitats *Chlorella* species is used to grow zoo plankton which in turn is consumed by shrimps. Shrimps are grown directly on microalgae *Skeletonema costatum*. Besides, oysters and clams are also grown on cultured diatoms and microalgae, fishes like *Tilapia* and silver carp are fed on cultured blue green alga *Anabaena*. Larger algal forms are considered as delicacies in Japan, China and far east countries.

Experiments conducted at the Central Food Technological Research Institute, Mysore have shown that the microalgae *Scenedesmus acutus* and *Spirulina platensis* could be cultivated on a large scale and used as food and feed as they are rich in protein, essential amino acids and vitamins and their nutrient value is comparable to conventional foods.

The growth of cyanobacter, green and purple sulphur bacteria, symbiotic and non-symbiotic nitrogen fixers and other heterotrophic microorganisms on renewable substrates waste waters, industrial effluents using solar energy not only enhance pollution control but improve bio-productivity and energy.

The blue-green alga BG-7 has been found to produce 230 μ moles of hydrogen per mg chlorophyll per hour from water which could provide energy upto 1000 kWh/month. This energy could be produced by growing the alga in a pond 1 meter deep with a surface area of 64 square meters.

Although a considerable amount of work has been done on heterotrophic microorganisms like yeasts, fungi and certain bacteria for the production of single-cell proteins, organic acids, vitamins, antibiotics and hormones, the use of photo-

synthetic bacteria for harnessing solar energy and waste treatment is relatively a very recent field specially in India.

It has now been shown that the photosynthetic bacteria play an important role in purifying the industrial effluents in addition to their activities of nitrogen fixation as well as assimilation of carbon dioxide utilising solar energy.

Rice plants to which photosynthetic bacteria had been applied showed increase in number of grains per year and also an increase in their total weight. The use of these bacteria on tomato plants has been shown to increase their yield by 455%. There was also increase in the carotene and vitamin contents of their fruits. These bacteria supplemented in chicken feed at the level of 0.01%-0.04% were found to increase the egg laying rate of hens by 10%.

During our investigation on the use of photosynthetic bacteria to harness solar energy and to purify sewage it was found that both the green and purple non-sulphur bacteria were efficient in lowering the B.O.D. (biological oxygen demand) of the sewage. *Chlorobium limicola* and *Rhodospseudomonas sphaeroides* isolated from the estuaries of Goa reduced B.O.D. of domestic sewage from the initial 300ppm-350ppm to 20ppm over a period of 28 days. The untreated sewage control showed a reduction from 80 ppm to 180 ppm only.

About 8% of the world fish production comes from aquaculture. Aquaculture, being a labour intensive industry, holds promise of employment generation in developing countries like India besides utilising earth's surface that has not been exploited systematically. In the course of our study in Goa on fish *Tilapia mossambica*, it was observed that the fish fed with the photosynthetic bacteria grew faster. Unfortunately research and development in smaller university centres have not been encouraged.

The scope of use of photosynthetic bacteria in waste water treatment, aquaculture, agriculture and biomass production is promising. The results so far obtained from laboratory experiments should be extended to

field trials and the results made available to the society.

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Antimalarials—development and synthesis

THE use of cinchona bark discovered in the 16th century was perhaps the first specific remedy for malaria. But the demand soon became astronomical, resulting in stripping all the accessible South American forests of the material. During the II World War, Japan seized more than 90% of the natural resources of quinine leaving the rest of the world dependent on other sources for combating malaria. The production of synthetic antimalarials at that time was negligible compared to the annual world production of quinine (about 1,000,000 kg) and Germany was the only country which had shown some interest in synthetic antimalarials.

Realizing the gravity of the situation and finding the high incidence of malaria in many of the battle areas, the medical division of the American armed forces initiated a programme for the chemoprophylaxis and chemotherapy of malaria in early forties. When the Americans entered the War, a drug called mepacrine was available for treatment of malaria. American chemical companies started manufacturing the drug in quantities large enough to meet the requirements of the armed forces as well as the civilian population. During this prophylactic campaign some disadvantages associated with mepacrine became apparent. These side effects and the effective propaganda by the Japanese that the drug rendered men sterile made it very unpopular.

At this time another antimalarial programme was initiated under the supervision of the American government to prepare more effective anti-

malarials with fewer side effects. The search for superior antimalarials began, keeping in mind the presence of quinoline nucleus (Fig. 1) in the then known antimalarial drugs, quinine and mepacrine. The established activity of the 8-amino-quinolines provides the additional rationale. The first of the synthetic antimalarials investigated in this programme was chloroquine. This compound was found to have excellent activity against avian malaria. About the same time, the German prisoners of war were found to possess a very effective anti-malarial drug identified as 7-chloro-3-methyl-4-(4-diethylamino-1-methyl-butylamino) quinoline called santoquine. These facts provided the necessary impetus for the enhanced thrust in developing other 4-amino-quinoline compounds as antimalarial drugs. Several compounds have since been prepared having the 4-amino-quinoline nucleus with variations in nuclear substitution, carbon skeleton of the basic side chain and the nature of the terminal amine.

Generally, variations among nuclear substituents seem to affect biological activity. Although many compounds have been examined, it is difficult to predict exactly what activity a given compound will have. However, certain generalisations can be made, viz, (1) the 7-halo-4-amino-quinolines are most active. Halogen in a position other than 7 and dihalogen substitution consistently reduce antimalarial activity more than toxicity; (2) variation of the basic side chain generally had little influence on the antimalarial activity. Chain lengths of 2-5 carbon atoms

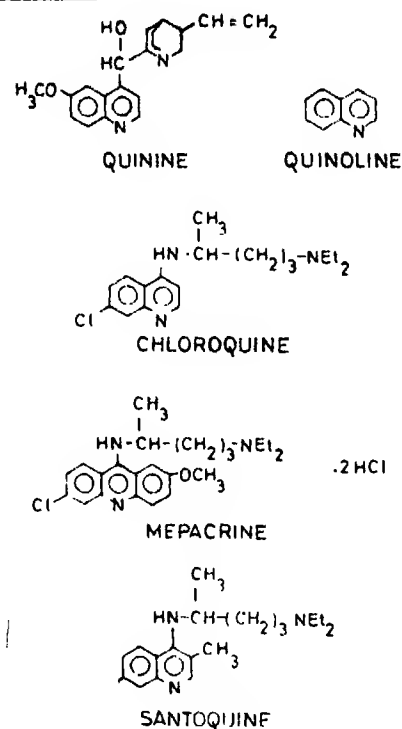


Fig. 1

were just about optimum; and that (3) variation among the terminal amines had little effect on biological activity.

After screening a large number of antimalarial drugs (about 14,000), which included pure compounds and natural products, chloroquine was found to be the most effective and suitable drug for combating malaria.

Clinical uses

Malarial infections are caused by intracellular parasites of the genus plasmodium. Among them the most important are *P. falciparum*, *P. vivax*, *P. ovalis* and *P. malariae*. They are usually transmitted through mosquitoes. Plasmodia get into the human system and develop through sequential stages. A suitably warm environment is needed for the development of the parasites. The mode of action of the parasite depends on the type of plasmodia involved. For example, in *P. falciparum* infection, the merozoites get into the blood circulation and penetrate red blood cells. This cycle is repeated, causing clinical manifestations of the disease but can, however, be interrupted on develop-

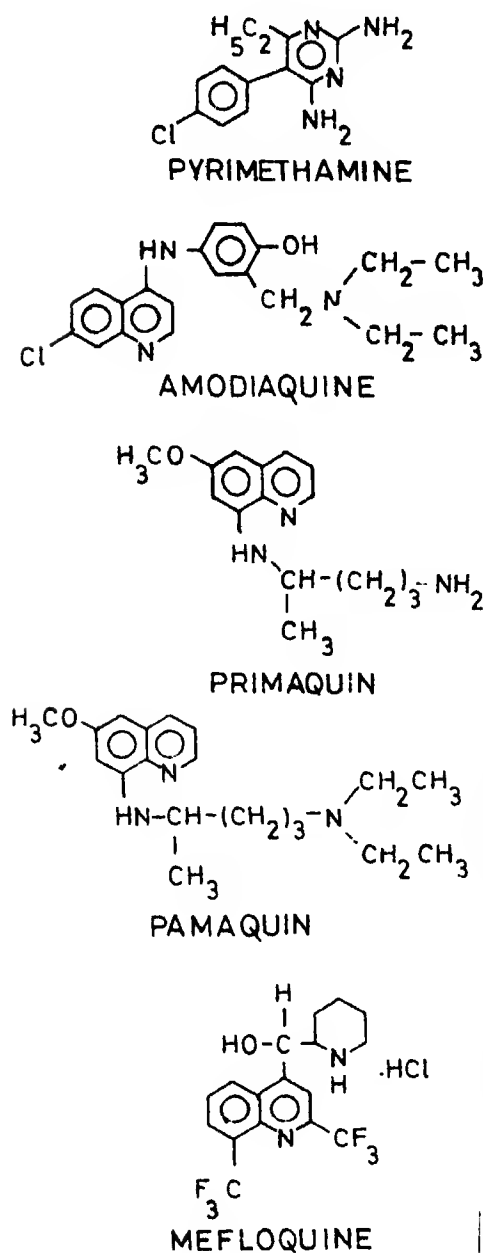


Fig. 2

ment of adequate host defence. Infections caused by *P. vivax* and *P. ovale* have a more complicated development cycle. These infections usually affect liver cells and sometimes show up immediately, but in other cases they remain dormant for extended periods of time resulting in clinical relapses. Antimalarial drugs act by affecting one or more developmental stages of plasmodia species. Some of the currently used popular antimalarial drugs are quinine, mepacrine, chloroquine, pyrimethamine, amodiaquine, pamaquin,

primaquin and mefloquine.

Synthesis of some important antimalarials

Intensive and concerted research efforts on synthetic antimalarials culminated in several useful syntheses of chloroquine and amodiaquine. The major challenge involved in the syntheses of these two drugs was the industrial feasibility of the synthesis of the intermediate 4, 7-dichloroquinoline. Several synthetic routes have been described in the chemical literature but most of them, except *EMME* route, have not found their

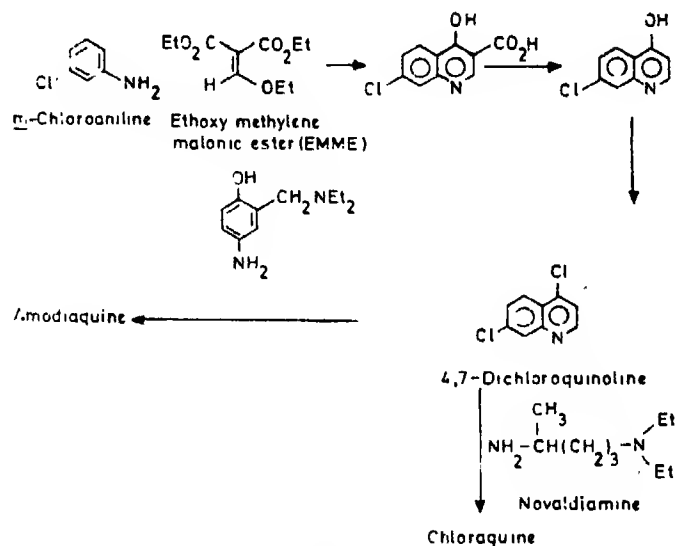


Fig. 3

application in the manufacture of the above drugs. In this route *m*-chloro aniline is condensed, with ethoxy methylene malonic ester (EMME) to give 7-chloro-4-hydroxy quinoline derivative which, through a sequence of reaction, is converted to 4, 7-dichloro quinoline. 4, 7-dichloroquinoline can be successfully converted to chloroquine and amodiaquine as shown in Fig. 3. All the steps are high yielding in this method and this is the most popular synthesis of chloroquine which has been fully exploited by industries.

Table 1

Antimalarial	Measuring Unit	Estimated Requirement			Rate of growth %
		1982-83	1983-84	1984-85	
Quinine	kg	10,650	11,750	12,900	10
Chloroquine	MT	335	365	400	10
Amodiaquine	MT	61	70	80	15
Primaquine	kg	580	610	640	5
Mepacrine	kg	375	395	420	5

Table 2

Antimalarial	Measuring units	Production	
		1981-82	1980-81
Chloroquine	MT	34.62	43.26
Amodiaquine	MT	23.15	22.24
Primaquine	—	—	—

SCIENCE SPECTRUM

Antimalarial drugs in India

Malaria is rampant in many of the South Asian countries, especially India. Chloroquine and amodiaquine are the two most widely used antimalarial drugs in India. Quinine from the natural source is also used to some extent. Table 1 illustrates the demand situation of the antimalarial drugs in India. Among these antimalarials, chloroquine and amodiaquine are made indigenously to a certain extent, whereas the demand for primaquin is met totally by imports. Table 2 gives the details of production. These figures indicate a large gap between the demand and production of chloroquine, the widely used antimalarial. The gap is being met by imports.

Conclusion

An enormous input has gone into

the discovery and development of effective drugs for the treatment of malaria. However, resistance of plasmodium strains against given drugs poses a serious threat. Another problem which has added a new dimension is the varying proportions of resistant strains to susceptible strains, depending on the geographical location. Because of this, the choice of the antimalarial will vary from country to country and may change with time in any given area. Drug combinations and sequentials seem to reduce the resistance problem.

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Bamboo—the tree grass

BAMBOOS are plants of great economic importance to the people in several parts of the world, but nowhere is their usefulness as great as in Asia. Bamboos are used for house construction, mats, baskets, fencing, tool handles, toys, musical instruments, furniture making, pipes, handicrafts, paper making, fuel, food and fodder. In fact, uses of bamboo are limitless and it is indeed difficult to imagine what the people in Asia would do without it. Bamboos have age-old connections with the common people, hence aptly called the "poor man's timber". The strength of bamboo culms, their straightness, lightness combined with hardness, range in size, abundance, easy propagation coupled with fast growth, and early maturity make them suitable for a variety of purposes. It has been estimated that one-third of human race uses bamboo in some way or other. In short, bamboo finds its use from the cradle to the coffin.

Distribution

Bamboos have a tree-like habit, yet they are members of the grass family *Gramineae*, hence are called the tree grasses. They occur mostly in natural vegetation of tropical, subtropical and temperate regions of the world, although in great abundance in tropical Asia. There are about 1,250 species of bamboos under 75 genera. The countries rich in bamboos are Bangladesh, Burma, China, India, Japan, Malaysia, Philippines, Srilanka and Thailand. Bamboos also grow in Bhutan, Korea, New Galedonia, Papua New Guinea, etc.

Bamboos vary greatly in size, from small to towering poles as high as 35 metres as in the case of giant bamboo, *Dendrocalamus giganteus* (Fig. 1). They have erect, jointed and generally hollow cylindrical stems, though, a few of them are climbers. At young age they are covered by sheaths. With the advancement of



Fig. 1. A clump of giant bamboo *Dendrocalamus strictus*

maturity sheaths gradually fall off. Normally, all bamboos are green except a few having golden colour. They can grow almost everywhere : from the sea-level to the snowlines, however they flourish most in hot, humid forests.

Cultivation

Bamboos are generally propagated vegetatively, although they are best raised through seeds. Seedlings are



Fig. 2. Bamboo clumps showing gregarious flowering



Fig. 3. Bamboo being felled after gregarious flowering

raised in nursery beds in drills and allowed to develop for a year after which they are transplanted in the field. In bamboos seeds are rarely available, that is why they are propagated through rhizomes, offsets or culm cuttings. In rhizome planting 1-year old culm with roots are dug up, cut to about a meter high and planted during the rainy season. Vegetative propagation of bamboos is an age old method and is practised in India, Bangladesh and Burma. While planting the pieces, the workers should take extra care not to injure the junction of the culm and rhizome. They should be planted as soon as possible after being dug. Irrigation is necessary after planting.

Natural regeneration of bamboos also takes place in the forests by seeds or by sprouts from rhizomes. Growth of young shoots is very fast in some species and can grow as fast as 0.6 m to 1.0 m a day. Once a forest officer kept his hat on a shoot and forgot to collect it. When he returned to collect it the next day, he could not reach the hat from the ground. The shoots grow to full size

in about 2 months time. The culm sheaths remain attached for the whole year and then fall off gradually. The shape and size of sheaths vary greatly among the species and are effectively employed in bamboo identification. Normally it takes around 10 years for non-clump forming species to reach harvesting size, but the time is shorter for clump forming types.

Flowering

Most bamboos flower only once in their life-time and die soon after (Fig. 2). Bamboo flowering is a mystery to scientists. Probably they have an inbuilt alarm clock, when it is set to go off at a particular time, all population of a species raised from a single seed source will start flowering no matter where it is situated. Even a few months old young shoots will flower along with the old ones. Once a population of bamboo, raised from the same seed source in Dehra Dun and Calcutta 1500 km apart and with totally different climatic conditions, started flowering simultaneously. The flowering cycle generally varies from

7-120 years, in some, the interval is 3 years or so and a few may even flower annually. Some bamboos, however, have rarely been observed to flower.

The exact cause of bamboo flowering is not known. It is believed that a short rainy season followed by a long spell of hot weather promotes flowering. That is why perhaps bamboo flowering has been associated with superstitions like it is an indication of famine or epidemic. It has also been associated with an increase in rat population. It can be explained on the basis that gregarious flowering of bamboos produces enormous seeds which are eaten by rats and their reproductive cycle is short, within a short period there will be millions of young ones. The result is that the rat population reaches an astronomical figure in a small area.

Bamboo as food

The succulent shoots of many bamboos are highly nutritious and palatable. In India, Bangladesh and Burma shoots are used in pickles and curries. In Thailand shoots are eaten fresh, pickled and dried forms. In the Philippines bamboos are cultivated for shoots. In Taiwan, shoots are processed, canned and exported and millions of dollars are earned. In Japan also bamboos are cultivated for shoots. Generally shoots are collected when they are about 4cm-7cm long. In Korea, at a managed bamboo farm, it has been possible to collect about 10,000 kg shoots per hectare. Harvesting is done only once a year. Research on taste of shoots is also carried out. Shoots of most bamboos are edible, however around 26 species are generally used for the purpose. In India, bamboo shoot farms are yet to be established, although it has potential of earning foreign exchange from bamboo shoots. Besides shoots, seeds of many bamboos are used as food by human beings especially during famine. Birds and rodents also



Fig. 4. Bamboo culms stacked for transport

eat bamboo seeds in large quantities.

Bamboo in India

India is very rich in bamboo resources. With about 22 genera and 136 species, it is one of the largest resources of bamboos, perhaps next only to China with 26 genera and 300 species. The areas particularly rich in bamboos are Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura and West-Bengal. Other areas rich in bamboos are Andamans, Baster region of Madhya Pradesh and Western Ghats. A few bamboos are also found in other parts of India both in the hills and plains. The important genera are *Arundinaria*, *Bambusa*, *Cephalostachyum*, *Chimnobambusa*, *Dendrocalamus*, *Dinorchloa*, *Gigantochloa*, *Indocalamus*, *Melocanna*, *Neohouzeoua*, *Ochlandra*, *Oxytenanthera*, *Phyllostachys*, *Pseudostachyum*, *Sehizostachyum*, *Semiarundinaria*, *Sinobambusa*, *Teinostachyum* and *Thamnocalamus*.

Bamboos cover an area of 9.57 million hectares or about 12.8% of

the total forest area of the country. The annual output is estimated at about 3.23 million tonnes, which is one-fifth of the country's total wood production. More than half of the production is consumed by the paper and rayon industries alone. Nearly 80 paper mills depend wholly or partly on bamboos as they are the only long-fibred resources easily available to the industries. Bamboos therefore constitute one of the most important renewable natural resources of the country, but they are not being utilized to the maximum. Of nearly 136 species, only about 10 are being commercially exploited. They are *Bambusa arundinacea*, *B. balcoa*, *B. tulda*, *Dendrocalamus hamiltonii*, *D. strictus*, *Ochlanacea*, *B. balcoa*, *O. seriptoria* and *O. travancoriea*. The bamboo industries in India are in their infancy, especially in the handicrafts sector. But India leads the Asian countries in the utilization of bamboo for paper manufacture. Like paper industries, bamboo-handicrafts industry also requires to be developed to the fullest extent so that bamboos can be used

for maximum benefit of the common people.

The Forest Research Institute Dehra Dun, has the richest collection of bamboos in India. It has about 35 species conserved in several arboreta and are being investigated with multidisciplinary approach, e.g., taxonomy, breeding, timber engineering, silviculture, pulp and paper technology, etc. Bamboo seeds, when available, are supplied by silviculturists to the states and persons interested in raising bamboo plantations.

Research

In the past bamboo research in India was concentrated on *Dendrocalamus strictus*, because of its importance in paper industry. Research is in progress on evolving suitable methods of seed storage, identification of bamboos on the basis of culm sheath, clonal trials, etc. India now plans to establish 3 major centres of research and development for bamboos: one in Assam, one at Dehra Dun, one in Kerala. Previously distant crosses between bamboo and sugarcane were attempted; this is again being considered. The research on priority basis in bamboos includes: raising bamboo germplasm banks for conservation, breeding high yielding varieties, propagating bamboo by tissue culture, undertaking trials on irrigation and fertilizer application, evolving effective methods of storage, and initiating research on bamboo culm preservation. Research may also be taken up to grasp the techniques of promoting or inhibiting flowering to evolve hybrid varieties. Bamboos should also be included as one of the species in social forestry programmes.

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Can fly-ash be used as micronutrient carrier ?

COAL is undoubtedly the prime source of energy in India. It has been estimated that, to meet the increasing energy demand, our coal production may have to be raised from 100 million tonnes per year (1980) to 400 million tonnes by the turn of the century. Much of this coal is being used in thermal power plants for generation of electricity. At present 60 per cent of electricity in India is being generated by such plants. While energy is the brighter side of coal combustion, pollution of environment is the darker aspect of this process.

The amount of fly-ash (an amorphous ferro-alumino silicate) produced by burning of coal in thermal plants is enormous; at present it is dumped in low lying areas near power plants. Because of the presence of several natural elements (numbering 54) and being alkaline, application of fly-ash on land has a marked effect on soil physico-chemical properties from the point of view of crop production. Various studies conducted in India and abroad have indicated that application of fly-ash to soil reduces the bulk density and increases water holding capacity of soil mixtures. Surprisingly, while this decreased bulk density made the soil more prone to wind erosion, the increase in water holding capacity did not produce any significant increase in plant-available water. In certain cases, the cementing nature of fly-ash results in water-logging which could be overcome by better agronomic practices.

Perhaps the limiting factor in fly-ash utilisation on land are unfavourable changes in the soil's chemical equilibrium affecting its pH, salinity and levels of certain toxic elements. As a result of hydrolysis of calcium and magnesium oxides in ash, pH of soil increases. Prof. A.L. Page of California has observed that by application of fly-ash to soil at a rate

of 8% by weight, pH of calcareous soil increased from 8.0 to 10.8, whereas that of acidic soil increased from 5.4 to 10.0. Should then application of fly-ash be recommended for reclamation of acid soils? No, because by reducing acidity there emerges deficiency of nutrients like phosphorus, zinc and copper while molybdenum, selenium and boron contents increase to levels toxic to plants.

In spite of these drawbacks, there are reports of increase in dry matter yields of crops like alfalfa, wheat and paddy grown on fly-ash amended soils. But the increase in yields is due primarily to correction of either macro- or micro-nutrient deficiencies. Of the essential plant nutrients, concentrations of sulphur, molybdenum and boron in plant tissues have been shown to increase consistently with ash application to soil. Even concentrations of non-essential trace elements—aluminium, selenium, arsenic, barium, vanadium, etc.—consistently increased in plant tissues with ash application.

Yields of several crops were found to increase by addition of fly-ash by weight to soil. Increase in yields were attributed to the correction of nutrient deficiencies of sulphur in plants. But increase in yield of rice grown on fly-ash amended soils was attributed to decrease in toxicity of aluminium and manganese brought about by the neutralizing action of fly-ash. Because nitrogen content in fly-ash is usually nil and its phosphorus content is quite insoluble, these nutrients should be added to sustain good growth where fly-ash is applied. In certain cases, inconsistency is observed regarding the uptake of potassium, calcium and magnesium by plants. This is due to the interaction of these elements rather than any other factor. The micronutrients such as manganese, zinc, copper and iron from fly-ash are not consistently available to plants. Increase of

alkalinity is the main cause of nutrient deficiencies.

While application of fly-ash reduces availability of certain plant nutrients, there are certain elements which are available in concentrations beyond toxic levels. Of importance are boron, molybdenum and selenium. Due to neutralizing action of fly-ash, high fly-ash inputs to soil could increase molybdenum in forage crops to levels potentially toxic to animals feeding on it. It may result in a disease called 'molybdenosis' of the animals. Similar is the role of selenium in animal nutrition. Small amounts of molybdenum and selenium are essential to animal nutrition. But continued consumption of forage with elevated molybdenum and selenium contents may induce physiological disorders in animals. Boron in fly-ash is also readily available to plants; in fact, several scientists consider boron to be a major factor limiting successful cropland utilization of fly-ash. Although cadmium, fluorine, mercury, nickel and beryllium are also considered potentially hazardous to animals, elevated levels of uptake by plants grown in fly-ash affected soils have not been demonstrated.

If lands are to be used for fly-ash disposal, application rates should be balanced between environmental impacts and economics of waste disposal. Massive applications usually lead to nutrient toxicity and increased salinity. But coal ash, used in conjunction with high carbonaceous materials such as sewage sludge, peat and animal manures, can be safe.

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Proteolytic enzymes from plant latex

PROTEOLYTIC enzymes are tools which have been used in

SCIENCE SPECTRUM

medicine and industry for hundreds of years. Several proteolytic enzymes have been isolated from plant latices. Latex is a milky fluid present in the specialized cells (latifers) of the plants. Latex has been found in more than 12000 plant species. *Apocynaceae*, *Asclepiadaceae*, *Asteraceae*, *Caricaceae*, *Euphorbiaceae*, *Moraceae* and *Sapotaceae* are the major families of latex-bearing plants. The most important proteolytic enzymes, papain and chymopapain have been obtained from the latex of *Carica papaya*. Other proteolytic enzymes from latex are: ficin from *Ficus carica* and some other species of *Ficus*, calotropain from the latex of *Calotropis gigantea* and *C. procera*, and asclepain from *Asclepias speciosa*. The above mentioned enzymes have been isolated in crystalline form. Proteolytic enzymes occur in the latices of several other plant species also.

Papain

Commercial papain is a mixture of several enzymes and is isolated from the latex of the green fruits of *Carica papaya*. High quality papain is crisp and creamy white. It is a typical protein digesting enzyme and is active over a wide pH range. It catalyses hydrolysis of peptide bond in a protein molecule and also has the milk clotting activity. Activity of the papain is lost above 70°C.

Chymopapains

Three types of chymopapains (chymopapain A, B and C) have been obtained from papaya latex. Chymopapains have the same milk clotting activity as papain but their protein digesting activity is lower. Peptidase A and B, isolated from papaya latex are also proteolytic enzymes but are less reactive than papain. Glutamine cyclotransferase and lysozyme have also been isolated from the latex.

Ficin

Ficin is a loose term used to designate the crude latex of *Ficus* species as well as the purified preparations obtained from it. Proteolytic activity is exhibited by many *Ficus* species. The most specific activity is present in the latex of *F. stenocarpa*, *F. carica* and *F. glabrata*. Ficin resembles papain in most of its properties. It catalyses hydrolysis of a number of natural and synthetic substrates.

Calotropins

The latex of *Calotropis gigantea* contains calotropins D I and D II and calotropains F I and F II and possesses strong proteolytic activity. The enzyme calotropain with marked proteolytic activity has been isolated from the latex of *C. procera*. The enzyme is more active than papain, ficin, etc.

Uses

Papain finds wide use in food industry for tenderizing meat and in the brewing industry for making "chill-proof" beer. In USA it is used in the manufacture of chewing gum. It is used extensively in degumming natural silk when it is mixed with rayon or woollen fibres for weaving. It is also used in cosmetics, dental pastes, and leather industry for bating hides and skins. Papain, chymopapain and ficin are well-known milk clotting enzymes and are used in making cheese.

The latices of *C. papaya*, *Calotropis* and *Ficus* showed anthelmintic properties. The latices of *F. carica* and *C. papaya* have been found to be effective against dog ascaris. Papain exhibits anthelmintic action on *Haemonchus contortus* in sheep. Calotropain showed anthelmintic activity against the common pathogenic worms of sheep and goats and has been found to be more active than phenothiazine. Presence of blood

anticoagulant factor has been reported in the latices of *C. papaya*, *C. procera*, *F. carica* and some other plant species also. Calotropain also possesses anticoagulant property. Papain is used in medicine as a protein digestant, for combating dyspepsia and other digestive disorders. It is used in the treatment of bleeding piles, diphtheria, chronic and infantile diarrhoea, various skin lesions including eczema and ringworm, certain types of infertility and sloughing of wounds. The latex of *F. carica* has been found to possess inhibitory action on transplanted and spontaneous tumors of mice. Papain and calotropain also show anti-inflammatory activity.

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Guayule—a rubber-yielding plant

GUAYULE (pronounced Why-00-Lee) means literally the plant from which balls are made. When the Spanish first came to America they found the Aztecs playing football with a ball made from this natural elastomer by "smoking" it. A native of semi-arid regions of North Central Mexico and Southern Texas, this blue-flowered plant, botanically known as *Parthenium argentatum*, was found to contain 10% to 20% rubber, which is in every respect equal to the hevea rubber.

The First World War forced the Americans to start the Emergency Rubber Project (ERP) to manufacture rubber from guayule. One thousand scientists and 9000 workers were employed and 15 tons of rubber was produced per day. But the ERP project was abandoned in 1943, after



Fig. 1. *Parthenium argentatum*

the great success of synthetic rubber. The world oil crisis of early 1970s put the synthetic rubber industry under great strain because it depended on petroleum for its raw material. Increased petroleum prices resulted in a steep increase in the price of synthetic rubber and consequently natural rubber prices rose to keep pace with the synthetic rubber prices. With demand outstripping supply, and the long growing cycle of the rubber tree makes it impossible to increase production quickly. Economic experts have forecast a worldwide shortage of more than 500,000 tons of *Hevea* rubber within 10

years. Rubber from the guayule plant might help in countering the anticipated shortage of natural rubber. In India, guayule can be cultivated in desert conditions as obtained in Rajasthan and Punjab. Just as the *Hevea* rubber tree, originally a native of Latin American countries got established well in Kerala, Srilanka, Malaya and other places having uniformly distributed rain forests, guayule from the American deserts can also thrive well in the Indian desert areas. Working on this clue, the Central Arid Zone Research Institute in Jodhpur, and the National Botanical Research Insti-

tute in Lucknow, are raising the plant on an experimental basis and envisage a large scale planting programme shortly.

Guayule is usually propagated by nursery grown seedlings. It grows upto about 1m high and requires little water. It is amenable to genetic improvement and can be harvested in two or three years time. It can live for 30 to 40 years or even more under desert conditions where rainfall may be less than 250 mm. It can be harvested on rotational basis every 2 to 6 years, and like all arid region plants needs a great deal of sunlight and low night temperature. A two year-old plant produces atleast 10% rubber by dry weight. With chemical stimulants rubber production can be increased at early stages of growth to as much as 300%.

It has been found that the freshly harvested shrub can be successfully processed for recovering its rubber. In guayule, the rubber hydrocarbon is suspended in latex as in other rubber-bearing plants. However, the latex in guayule is not borne in long tubes or ducts but are found in single cells principally in the cortical tissues, medullary rays and in the pith. Since they are not interconnected, the latex cannot flow readily from one cell to the next. Therefore, unlike in *Hevea* where the rubber is collected by tapping, the whole plant is harvested in case of guayule. Harvesting can also be done by pollarding, or ratooning. This is done by lopping off the tops of the plants, leaving the crown and root system intact which would permit successive crops of rubber from the same plant and eliminate the cost of re-establishing plantations after harvests.

Mill yield of rubber from the freshly harvested latex is generally high, but the method of preparing the shrub influences recovery of rubber hydrocarbon. When the shrub is conditioned and stored under conventional methods of large-scale operation, the yield of rubber hydro-

carbon decreases, with increasing storage time. After harvest the raw material should be transported to the processing unit immediately, as they do not keep for long, or else the processing unit should be located near the field.

Chemical extraction of rubber can be done by maceration of plant material by organic solvents, such as benzene or toluene. As the yield of rubber by this method is very poor, this has been replaced by mechanical method which consists of crushing the plant materials to separate cork and rubber by adding pebbles and water in the mills. After de-corking, the rubber is sheeted out on rolls to remove a large part of water after which the product is considered ready for the market. Present day extraction methods are only a modification and improvisation of the mechanical process.

Crude guayule rubber contains little or no natural antioxidant or preservative, as does the tree rubber. Therefore, they are treated with antioxidants and preservatives before marketing.

Chemically the rubber hydrocarbon molecule from guayule is the same as Hevea rubber and the crudes have been used for everything from over-shoes to adhesive tapes. Guayule rubber has excellent tack and adhesive properties and has been found to be useful in the manufacture of plied articles, such as footwear, belting, hose and other mechanical goods where adhesiveness to fabrics is essential. Guayule rubber vulcanises like Hevea rubber and has the nature and tack crucial for tyre manufacture. Experimental radial tyres containing 30% to 40% of guayule rubber produced in America have passed all U.S. Department of Transportation high-speed and endurance tests.

Guayule also yields byproducts like high quality rubber-free wax from leaves and useful resins. The plant may even provide its own fuel; bagasse, the pulpy residue left

after extraction of rubber is a good energy source.

An important point in favour of guayule is its ability to grow well in arid and marginal lands. Hevea, on the other hand, requires fertile land and a humid climate which limits the possibility of expansion of its cultivation. Another advantage with

guayule is that it is a shrub and comes to commercial production in about three years. It is easy to handle since no tapping of latex is required and the whole plant can be processed for rubber.

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Prosopis juliflora (Swartz) DC —a fuel tree for sodic soils

SCARCITY of firewood has become a severe problem, no less severe than the scarcity of oil which brought about an energy crisis with alarming suddenness in 1973. It is not widely appreciated that wood is the fourth largest source of energy after coal, petroleum and natural gas. More than one quarter of world population depends on firewood and its derivative charcoal for cooking and heating. In rural India, an average consumer burns 0.5m³ wood a year. Even this modest consumption, under increasing demographic pressure, has resulted in a dangerous imbalance between requirements and available supply of firewood. The shortfall in firewood production by 2000 AD is estimated at 137 million tonnes. Considering that firewood, far from being overtaken by other energy sources, is likely to remain the principal fuel in rural areas, an array of technological solutions has been suggested to augment supply of firewood. Creation of new resources of firewood is one of the options considered consonant with the potentialities and constraints of our economy. It is estimated that, at the existing level of contribution of wood to energy supplies, 34 million hectares of firewood plantations would be needed to meet the projected demand of firewood for the year 2000.

The concept of firewood plantations appears attractive if applied to saline and sodic soils which are unsuitable for traditional agriculture. They constitute a large potential source of land for fuelwood planta-

tions. However, a major constraint in utilizing these soils is that only a limited number of alkali-tolerant species can be grown. There is paucity of experience with cultivation of trees and shrubs explicitly for firewood on saline and alkali soils.

The woody biomass plantation research underway at Biomass Research Centre of the N.B.R.I. began in 1981 as part of a broad spectrum effort of examining plants for biofuel production. Various aspects of producing firewood biomass such as species selection, production, potential, nutrient accumulation, fuelwood characteristics, etc. are being studied. Eleven tree species, selected on the basis of rapid growth rate, ease of establishment, ability to resprout from cut stumps, and tolerance to high levels of soil exchangeable sodium, have been planted over an area of 10 hectares. The site soil is characterized by poor permeability, high pH (9-10), low electrical conductivity (430 mmhos/cm-995 mmhos/cm), and is underlain by a layer of calcium carbonate concretions at a depth of one metre. *Prosopis juliflora* (Swartz) DC, a tree native to Central America and northern South America grows remarkably faster than the other species, having attained a height of 3.3 metres and diameter of 3.1 cm in two years. Individual trees have grown as much as 5 cm in diameter and 6 metres tall. It has suffered very low mortality and shown excellent adaptability to the harsh environ-



Prosopis juliflora. Two-year old biomass plantation on sodic soil

ment of alkali soils. The fact that it grows successfully in situations where most other forest tree species would succumb testifies to its remarkable adaptability. In Kutch, a zone of high salinity, erratic scanty rainfall, rocky hills and sandy plains, *Prosopis juliflora* has been highly successful.

Historically, *Prosopis juliflora* has been used for fuel in all countries where it is cultivated. In the semi-arid regions of the world much of the fuelwood comes from natural stands of either *Acacia* or *Prosopis*. In World War II, wood was used to power steam locomotives and industrial boilers. *Prosopis juliflora* wood is hard and heavy (density 0.82), burns with a calorific value of 18.7 MJ/kg. Analysis of wood samples from trees growing on sodic soils has shown that the wood is siliceous, has 0.36 per cent nitrogen, 31.7 per cent cellulose, 39.5 per cent lignin and 9.6 per cent pentosans. High density and lignin content impart high heat of combustion of the wood. Proximate analysis shows 2.8 per cent ash, and 19.6 per cent fixed carbon. The wood is reported to yield charcoal of gunpowder quality and is termed

"anthracite coal" for its high calorific value. The rootwood is very hard, has little sapwood and is highly prized by chefs for barbecues as it burns with little smoke, imparting a fine flavour to the meat.

Prosopis juliflora appears to be one of the most suitable species as fuel plantation on sodic soils because of its tolerance of unfavourable levels of soil exchangeable sodium, rapid early growth, freedom from insect predation and fungal infection, high regeneration potential

and high heat of combustion. Its coppicing ability would obviate the need for replanting the site for successive plantations. *Prosopis juliflora* grows exceptionally fast. It is an aggressive invader forming dense spreading thickets. In Andhra Pradesh, millions of poor people earn their livelihood by cutting down *Prosopis* plants around their dwellings and on wastelands for disposal as firewood.

Limited work to date on plantation grown *Prosopis* shows that seedlings are exceedingly variable in growth and production. This may be attributed to an outcrossing breeding mechanism.

Prosopis juliflora is reported to reduce salinity and alkalinity of the soil after prolonged occupation. The soils beneath *Prosopis* trees show increased nutrient availability. Data from 2-year-old biomass plantations of *Prosopis juliflora* at Banthra show higher concentrations of organic C and N in the upper 3 cm layer of the soil in the root zone of the tree. The tree growth had no significant effect on soil pH. *Prosopis* species are able to fix their own nitrogen. This makes them all the more useful for semi-arid soils which are poor in nitrogen and organic matter.

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Video in the courtroom

WITH the rapid development of scientific technology, courts all over the world are being called upon to decide about the use of scientific evidence. It appears that in many cases the attempt to use such evidence succeeds, thus, striking a new line of approach or permitting fresh avenues for inquiry in the search for truth. Generally speaking, courts in the past did not respond very quickly to scientific advances or technological progress. They were found to be somewhat hesitant in

giving judicial recognition to such advances until the matter had been tried over a sufficiently long time, so as to eliminate any chances of error. However, of late, the response of the courts has been found to be quick and newer types of scientific evidence are increasingly being given recognition in the courts.

Video tapes

Most interesting developments have taken place after the invention

SCIENCE SPECTRUM

of television and video. Video tapes have been very useful in facilitating identification in criminal cases. In one of the cases in England, theft of a bottle from a shop was recorded on video tape. From the video tape, a security officer recognised the thief as D. At the trial, the security officer gave evidence to the effect, and the jury also saw the tape. D was convicted of theft and his appeal was dismissed. The appellate court held the evidence to be admissible. Of course, the weight of such evidence would depend on the circumstances. The English Court of Appeal has gone to the extent of holding that assuming the validity of a video tape is not challenged, there is no distinction to be drawn between the evidence of identification of one who has observed the tape and the evidence of one who has observed the event recorded on the tape.

Traditionally, courts adhere to the "best evidence" rule. But the recent tendency is to admit all relevant evidence. For example, K was convicted of taking part in a public disturbance with a large number of other youths. He had been recognised by a prosecution witness from a BBC television news programme. At his trial, the prosecution relied on a video cassette, as it was the policy of the BBC not to allow originals of their films to leave their premises; K called no evidence and was convicted. He appealed on the ground that this was not the best evidence, which was the original film. It was held, dismissing K's appeal, that the justices had been satisfied that the cassette was a true copy of the film, and the evidence was sufficient to support a *prima facie* case.

In 1982, a well-known producer had to enter into litigation with some firm, which had undertaken not to sell illicit video cassettes. The producer suspected that even after the undertaking, illicit sales were still going on. He placed "trap orders" with the firm and the firm tried to

explain how further illicit cassettes were sold. The question arose whether all this could be given in evidence. The Court held that the plaintiff was not debarred from relying on the purchase, merely because his agents had "trapped" the firm.

Video and film

A person who agrees to act only for a video cassette can legally claim that the performance should not be distributed as a film. On this reasoning, an actress could successfully sue a film producer, and film distributor for distributing, as a film, a cinematograph film where she had, by her agreement, limited her consent only to appearing in a video cassette.

Television sets in hotels

The provision of television in hotel rooms created problems in Sweden whose Supreme Court has recently held that the provision of radios and television sets in hotel bedroom constitutes, for copyright purposes, a "performance in public" where the hotel rooms are normally freely available to the public on payment of a hire charge.

Photofit pictures

One finds even "photofit" pictures figuring in criminal courts. These are pictures made after a crime and try to reconstruct, as far as possible, the physical features of the offender by eye witnesses. The pictures are later used for tracing the culprit. A photofit picture of the robber, made by an eye witness of the robbery, was recently used to confirm the identification of the culprit made by another witness.

The computer

Detection of theft is sometimes helped by computers. An accused person was convicted of handling stolen metals. The prosecutor had relied upon records in the processors' possession of the chemical composition of the consignment from which the relevant metals were alleged to

have been stolen. The records were copies of figures from computer print-outs, supplied by chemists. The computer had been programmed to make calculations from ratios fed into it to produce metal percentage. Similar tests were carried out on the metal handled by the accused (using the computer) to show that the metal had the same composition. It was held that the computer was being used as a calculator and was not contributing its own knowledge. The print-outs were not "hearsay", but real evidence. Proof depended on the testimony of the chemist and the relevance of the material depended on the chemist's testimony, testimony of the programmer and other expert evidence.

Telex and the law of contracts

In the law of contracts, one comes across the question of the development of telecommunications and its impact on the principles of contract. The precise question that has arisen is, at what place, and at what time, is a contract concluded, when the contract is by telex? It has been held that where telex communication is instantaneous, a contract is concluded at the place where, and at the time when, the acceptance of the offer is received by the offeror. Of course, where the communication by telex is not instantaneous, as for example, where the message is sent out of office hours or through a third party's telex machine, the question of the time and place of formation of contract (so made by telex) can be resolved only by reference to the intention of the parties, by sound business practice and, in some cases, by judging where the risk should lie, and not by applying a universal rule.

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MEDICAL NOTES

Control of poliomyelitis and vaccination

POLIOMYELITIS is an infectious disease epidemic and endemic throughout the world. It is caused by one of three types (Type I, II & III) of an ultra-microscopic enterovirus. It is principally an infection of the human alimentary tract but may affect the central nervous system resulting in irreversible flaccid paralysis. Man is the source of infection. The usual mode of transmission is the "faecal-oral route". The incubation period (time between infection and onset of disease) is about 7-14 days.

In the non-immune the virus can cause a generalised disease which can be divided into three parts—an initial incubation period, a prodromal non-paralytic stage, and a definitive paralytic illness. Only a small proportion of those infected ever become ill however, and less than half of those who become ill ever become paralysed. It is estimated that for every clinical case there will be at least 100 sub-clinical infections.

Geographic distribution

The disease mainly affects children under five in the developing countries in the tropics and subtropics and the disease still rages unabated and, in some instances, it is actually increasing (Table 2). The data available from many of these countries arise mostly from routine reporting systems which depend on the provision of reports from within

the health system. An assessment of this system has revealed that only 15% or so of cases occurring are detected and reported. If this correction factor is applicable to India, the number of cases in 1982 must be at least 99,000.

However, in the developed countries, the disease has been successfully controlled and in some countries the incidence has reached zero (Table 2). The age of onset of the disease in the developed countries is higher, and in Europe unimmunized adults are affected more commonly than children.

Forecasting the disease trend (Fig. 1)

It is becoming apparent in developing countries that as the infant mortality falls below 80 per thousand, due to a general improvement in health and sanitation, paradoxically the likelihood of epidemics of polio recurring increases. This is because the polio virus is normally endemic in most of these countries and, therefore, most children are infected with the virus during infancy when they are still protected with a high circulating level of maternal antibodies. They therefore acquire immunity to the disease without becoming paralysed as the maternal antibodies give them adequate protection against paralysis. As health and sanitation of a community improves, children are less likely to get sub-clinical infections as infants, and may

Public ~~Unit~~
~~be~~ infected instead for the first time at the age of 1 or 2 years or even much later when they have lost their maternal antibodies and protection. They will therefore be susceptible to paralytic poliomyelitis, and epidemics will become more frequent.

In communities with an even higher degree of hygiene, the age of acquiring the disease and immunity is much later. At present in Europe and North America only one-third of all new polio cases are under the age of five. No less than one-third are over 15 and one-third between the ages of 5 and 15.

Poliovaccines

Poliovaccination is once again in the news. There are two types of vaccines available: an inactivated (killed) poliovaccine-IPV or Salk vaccine and the other live attenuated (rendered safe) Oral Polio Vaccine-OPV or Sabin Vaccine. In 1955, Jonas Salk announced the development of his effective poliovaccine. Between 1953 and 1957, Sabin developed his vaccine. He thoroughly tested his vaccine on monkeys and humans including himself and members of his family. Both the vaccines proved to be safe and highly effective. Though safe and effective vaccines have been available for the past 20 years, it is unfortunate that poliomyelitis continues to be a major public health problem in most countries of the world.

Table 1. Problem of poliomyelitis in some developing countries

Country	Mean annual number of cases reported		Number of cases reported		
	1971-75	1976-80	1980	1981	1982
1. India	9162	14611	15470	19743	14974
2. Pakistan	1073	1243	1039	259
3. Egypt	1828	1053	2006	1605	2086
4. Turkey	445	297	182
5. Nigeria	384	601	816	289	261
6. Kenya	290	407	455	19	262

.... Data not available

Source: WHO—Weekly Epidemiological Record, 16 December, 1983



Fig. 1. Electron micrograph of polio virus

Vaccines controversy

The World Health Organization (WHO) currently recommends OPV for use in its expanded program of immunization (EPI) and it has been widely used in India. Endemic poliomyelitis has almost been eliminated in several countries with either OPV (e.g., the USA) or IPV (Finland, Sweden). There is no clear consensus about which type of vaccine is more effective, although most people would favour OPV because of its perceived ability to confer greater herd immunity. The contrary view that IPV exerts a profound herd immunity effect has been thoroughly reviewed and presented by Darell Salk.

Once the endemic poliomyelitis was brought under control in many countries, health economists took note of the rare adverse effects of the prophylactic vaccination. The attenuated virus of OPV was considered reverting to neurovirulence and it became established in a human population. Occasional cases of paralysis after the use of live vaccine (OPV), whether coincidental or attributable, were long recognized, and in 1969 the WHO sponsored a study of

this problem. It lasted over 10 years conducted in 13 countries. The results revealed that the rate of acute

persisting paralytic poliomyelitis with Sabin-like strains varied from 0.5 to 3.4 cases in recipients per million children.

Another concern about the use of OPV in tropical countries is the poor levels of seroconversion (about 78% after 3 doses) despite the use of vaccines of adequate potency. Reasons attributed to this include breaks in the cold-chain, interference with intestinal infection by other enteroviruses, presence of non-specific inhibitors in saliva, or other unknown factors. But Sabin pointed out that, where campaigns have been massive and sustained, results with OPV have been impressive, for example, in Brazil.

However, several small-scale investigations, in tropical as well as in temperate climates, have shown better and more consistent seroconversion rates with IPV than with OPV. Lately, the potency of killed

Table 2. Poliomyelitis situation in some developed countries

Country	Mean annual number of cases reported		Number of cases reported		
	1971-75	1976-80	1980	1981	1982
1. Australia	2	1	0	0	...
2. Denmark	0	0	0	1
3. Finland	0	0	0
4. Japan	5	0	2	2	1
5. Sweden	0	0	0	0
6. U.K.	8	5	2	3	...
7. U.S.A.	15	16	9	7	7

.... Data not available

Source: WHO—*Weekly Epidemiological Record*, 16 December 1983.

Table 3

Sabin vaccine (OPV)	Salk vaccine (IPV)
1. Live attenuated virus.	Killed formalised virus
2. Administered orally as "Drops"	Given intramuscularly or subcutaneously as an injection
3. Induces both intestinal (local) and humoral (circulating) antibodies.	Induces only circulating antibodies
4. Prevents intestinal infection by wild poliovirus.	Does not prevent intestinal infection by wild strains.
5. Highly effective in controlling epidemics.	Not helpful in controlling epidemics
6. Cheap (about 50 paise per dose)	Expensive—about 10 times costlier than OPV.
7. One of the most heat-sensitive vaccines.	Relatively heat-stable



Fig. 2. A cross-section of the spinal cord in the lumbar region showing destruction by poliovirus. The gray matter of a large area in the left anterior horn (A) has been completely destroyed which would lead to paralysis of the left leg. The right anterior horn shows partial degeneration (B). (Frobisher and Fuerst's *Microbiology in Health and Disease*, Fourteenth Edition, W.B. Saunders Company, Philadelphia)

poliovaccine has been improved and large-scale manufacture has been established by Merieux in France. This vaccine can be used in a two-dose schedule (interval six months) and produces excellent seroconversion; indeed, Jonas Salk argued that a single dose was sufficient to establish immunological memory and probably lifelong immunity.

In this connection it is also to be noted that in countries where poliomyelitis is endemic, there are large number of children having inapparent (or subclinical) infection with poliovirus and, any undue physical stress and injury particularly the injections, are known to provoke an attack of paralytic poliomyelitis (provocative poliomyelitis). This has been reported following even DPT (Triple Vaccine) injection. Hence, any additional injections including the IPV are likely to increase the risk of provocative poliomyelitis. This risk, though may appear theoretical, needs to be considered for practical quantification while evaluating the effectiveness of IPV in the field. If the IPV is incorporated in the DPT and given as a "Quadruple vaccine" (as in Canada & Holland) the additional

risk of provocative poliomyelitis is eliminated.

Problems of poliovaccination in India

At present the OPV is wholly imported and even after three decades of independence, it has not been possible to manufacture this life-saving vaccine in the country. Under the national EPI programme, OPV is administered to infants from the 3rd month in 3 doses of monthly intervals and a booster dose is given at 1½ years to 2 years of age. In urban areas the vaccine is provided through hospitals, maternity homes and health centres, and in rural areas through primary health centres. Besides, many voluntary organizations have periodically helped in organizing immunization camps.

Despite the availability of adequate quantity of OPV, vaccination coverage is about 42% of the proposed target. However, this is not due to poor acceptability of the OPV but due to other factors which include (1) ignorance about the availability of the vaccine, (2) inconvenient scheduling of the vaccination services, (3) inadequate handling of the vaccine logistics by the health staff, (4) poor mobilisation of community participation in immunization services, (5) poorly developed and frequent breaks in the cold-chain system, and (6) lack of initiative and drive on the part of the health staff to adapt vaccination strategies to suit situations and achieve targets. Besides other factors, like frequent power cuts, which in many parts of the country have become almost a daily feature would adversely affect potency of heat-sensitive vaccines which is normally stored in refrigerators in PHCs.

The current situation of poliovaccination is not very encouraging and now efforts are being made to ensure success of poliovaccination programme.

Introduction of Salk vaccine in India

In view of some of the above considerations, UNICEF has sponsored field study to introduce the new "high potency" Salk vaccine in India.

Till the results of the above study are known, it should be remembered that the OPV is still one of the safest vaccines in use and has the recommendations of the WHO.

Feasibility of global poliomyelitis eradication

At the international symposium on poliomyelitis control held in March, 1983 in Washington, the possibility of eradicating polio on a worldwide basis was considered. A few developed countries have accomplished local elimination, but only by achieving and maintaining a very high rate of immunization.

The problem of eradicating poliovirus is considerably different from that of smallpox. Poliovirus is more readily communicable, causes inapparent infection more often than not, and immunization, particularly with IPV, while conferring long-lasting immunity to disease, does not prevent the infection of gastrointestinal tract. Furthermore surveillance can be complicated by the fact that, without laboratory investigation, other causes of paralysis can be difficult to distinguish from polio. The temperature sensitivity of OPV, the considerable cost of IPV and the need to give it parenterally, pose practical problems that need to be surmounted if global eradication is to be considered.

WHO considers that a practical and feasible goal is worldwide control of paralytic polio within this century, but global eradication should not be abandoned as the ultimate goal.

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SCIENCE FOR THE YOUNG

Friedrich Bergius— a versatile scientist

BORN a hundred years ago, Friedrich Bergius was the man who was to score many a first in developing man-made substitutes for naturally occurring substances—coal, petrol, sugar and meat.

Karl Rudolph Friedrich Bergius was born on 11th October 1884 at Goldschmieden, near Breslau in Germany. His father, Heinrich Bergius, was head of a chemical factory in Goldschmieden. It was but natural that Bergius was attracted towards chemistry from a very young age. After passing high school in Breslau (now Wroclaw, Poland), Bergius went on to do a practical metallurgy course in the laboratory of a foundry in Ruhr. When he was nineteen, he joined the University of Breslau to study chemistry. Bergius then moved to Leipzig for higher education and obtained his doctorate in 1907 from Leipzig University.

Few scientists in the world could boast of a tutelage as distinguished as Bergius'. After securing his doctorate he worked with Nernst at Nernst's Institute in Berlin and later under the illustrious chemist, Haber, the man after whom the process of manufacture of ammonia is named, at Karlsruhe in 1909. Here Bergius learned the use of high pressure methods in ammonia synthesis; later in the same year, Bergius went to

Hanover to become a lecturer at the Institute of Technology. There he had the opportunity to work under Bodenstein.

During the early part of his long research career, Bergius worked on chemical transformations under high pressure. Initially he was interested in the transformation of wood into coal under high pressure and high temperature. He developed a process which yielded coal by carbonization of peat and cellulose. This man-made coal was similar in many respects to the natural one.

Bergius's work in the succeeding years, 1912-13, was on high pressure hydrogenation of coal and oil. It was about this time that Bergius became interested in the origin of petroleum and developed a process which was later known as the Berginization process. This process yielded world's first synthetic crude oil. The method was to hydrogenate coal dust under pressure, higher than 20 meganewtons/m², and convert it to oil without the formation of intermediates. This synthetic crude oil

could be refined into petrol, tar and light oils. Along with John Billwiller, Bergius was granted patent for this process in 1913. As this process was found to be industrially feasible, the patent rights were later acquired by I.G. Farbenindustrie, Standard Oil, and Imperial Chemical Industries. During World War II, Hitler's Germany used his method for oil production.

After World War II, Bergius pioneered the development of synthetic foods, especially sugar and cattle feed. Bergius and Hägglund developed a process by which complete hydrolysis of wood cellulose by concentrated hydrochloric acid yielded dextrose (sugar), and after transformation ethyl alcohol, or another secondary product which could be used as cattle feed. In 1946, Bergius came out with an ingenious method for preparing 'synthetic meat' from wood.

In 1931, Bergius and Carl Bosch shared the Nobel Prize for chemistry for their contribution to the "invention and development of chemical high-pressure methods". Bosch had developed an industrial process for nitrogen fixation and his methods were finding applications in ammonia industries.

It became difficult for Bergius to live in Germany in the post-World War II years. He founded a company in Madrid, Spain and in 1947 became Scientific Adviser to Argentine government.

Bergius, whose chemical processes helped industries both inside and outside Germany, the latter probably more, died on 30th March 1949 in Buenos Aires, Argentina.

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About penguins

THE bird kingdom has many members within it which are strange and peculiar in many ways. The penguins are a case in point.

They do not fly, but are excellent swimmers. On land they can get by with an entertaining sort of waddle. Penguins feel thoroughly at home in a

(about 55-25 million years ago).

Penguins belong to the order : Sphenisciformes and family : Spheniscidae, within which are six genera and eighteen species (according to some authors, sixteen). The second largest penguin (after emperor penguin) is the king penguin, standing about 95 cm high and weighing around 15 kilos. Though the king penguin is shorter than the emperor penguin by only 10 cm, it weighs just about half of emperor penguin.

The bodies of these birds are uniformly covered with water-proof plumage, except for the brood patch. The colour of the plumage is brightest just after moulting. At first glance, penguins seem to be only black and white, but a closer examination reveals plumage surprisingly varied and colourful. The colours fade as they grow older. The plumage, together with a 2 cm -3 cm thick subcutaneous fat beneath the skin, helps them keep effectively insulated against the coldest environment on earth. Moulting in penguins can be called 'catastrophic moulting', where all feathers are shed at a time. However, the old coat is pushed away only after the new feathers emerge from beneath. Because penguins are flightless, a complete moulting is no hazard to them.

Penguins are very clumsy on land but very agile underwater. They need

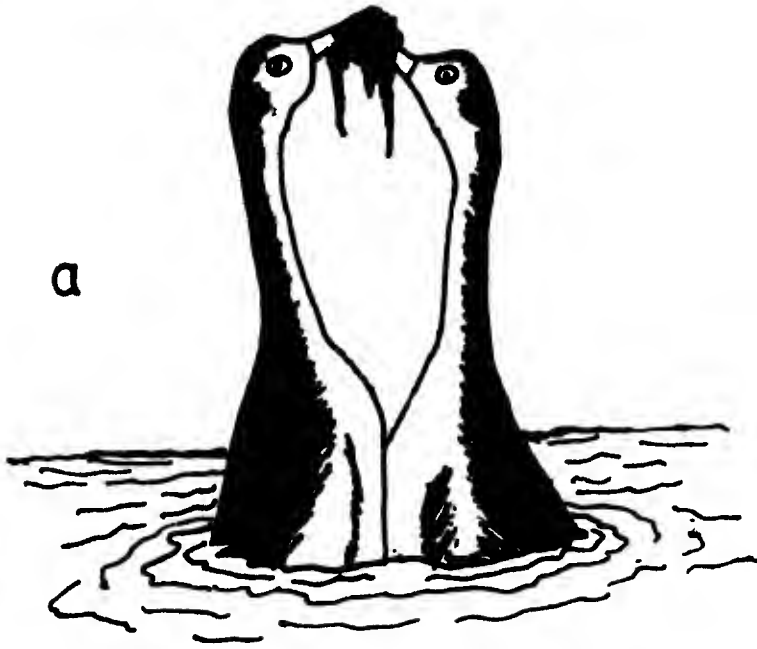


Fig. 1. (a). The courtship ritual

climate that humans find it inhospitable.

The Antarctic Ocean is as much a sea of birds as it is of whales. The entire Antarctic land too is dominated by penguins, so much so that the continent can be named as "Penguin's continent". Upright stance and waddling gait make them the most lovable of birds. Penguins are flightless birds, yet, they have a strongly keeled breast bone and powerful flight muscles. The wings are modified into flippers which help them swim easily, or rather literally, fly in water. The long spindle-shaped body has legs which are inserted far back so that they are most effective as oars and steering organs. The tail, as a steering rudder, is streamlined and triangular. Further their webbed feet help them in swimming in a most efficient way.

These birds are confined only to the southern hemisphere, and the majority of the species inhabit the cold Antarctic continent. However, some species are found even up to the equatorial region (Galapagos Islands) e.g., Galapagos penguin. Unlike most other flightless birds, penguins are very sociable and live in large

groups running into many thousands. Some species of penguins are exceptionally large, reaching up to a height of about 1.22 m (emperor penguin) and weighing up to thirty kilos or even more. The smallest penguin known today is the 'little penguin', reaching a height of 40 cm and weighing about two kilos. However a fossil of an early penguin is reported to weigh about 120 kilos. Totally 17 species have been described from lower Eocene to the beginning of the Miocene period

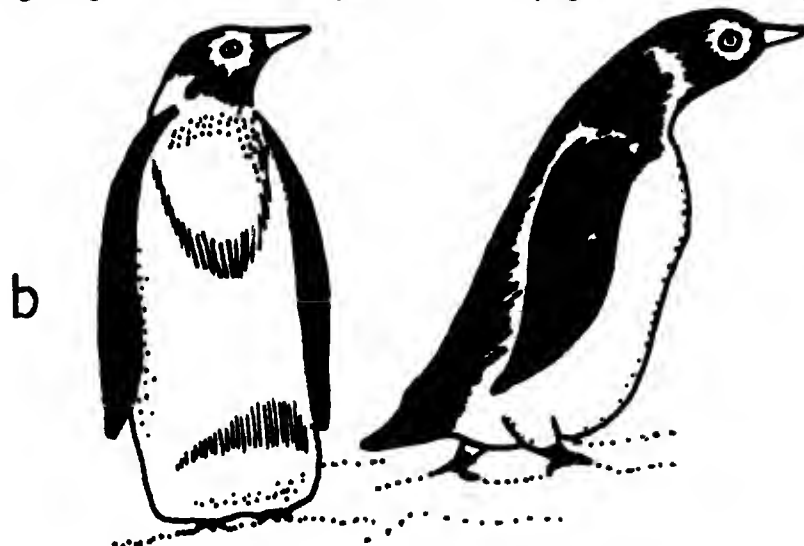


Fig. 1 (b). Adelie (*Pygoscelis adelia*)

SCIENCE FOR THE YOUNG

only an occasional fast flip to the surface to get air, and as they progress by porpoising upto about 27.5m and then shooting into the air in an arc of 2.13m-2.43m to vanish again with hardly a ripple. Most penguins dive head first, but 'rock-hopper' penguins make an awkward entry into the water by jumping with their feet first. On land or on ice, penguins walk with an upright posture, although in soft snow they slide on their bellies, or move by tobogganing on their chests while pushing with their wings and feet. On ice, adelic penguins can travel as fast as a man can run. Their food mainly consists of Antarctic krill, *Euphausia superba*, which are in plenty in that continent. Species living in places other than in Antarctica eat fish, squids, and crustaceans. Black-footed penguins take about half a kilo of fish per day. This species takes about 5 million kilo of fish per year from South African waters during the 185 days of the breeding season.

Penguins breed in huge colonies, some are reported to have as many as one million birds in a single rookery. They build their nests in open areas by making small burrows, or nests built with pebbles, plant twigs and other materials. The courtship ritual (Fig. 1a) in penguins can be called 'penguin dance', in which head shaking, diving and mutual presentation of waterweeds that serve as nesting material is often seen. This might have evolved from displacement nesting behaviour, initially produced by the conflict between hostility and sexual attraction. The female emperor penguin lays only one egg in a season, whereas others lay 2-3 eggs. The incubation period lasts from 33 to 62 days. During this period, the male bird incubates the egg by placing them on and inbetween their feet with a loose fold of skin of the belly covering the eggs to give sufficient heat to the growing chick inside the egg. The male birds usually do not feed during the incubation period, but female penguins wander

to collect food. As soon as the chick is hatched, both the partners take care of their young. Freshly hatched young are covered with a sparse, downy coat and are carefully brooded until at the age of six to ten days after which chicks can lead a relatively more independent existence. At the end of one year, the chick moults. They can begin breeding after two years of age.

An adelic penguin in its crowded Antarctic rookery would recognise its mate by voice when it returns after an absence of months. Chicks also respond to their parents' voice even when mixed up with thousands of other birds. An interesting feature of emperor penguins is that these birds are respected by other species in the locality, and they lord it over the others. Sometimes one can see a single emperor penguin controlling a group of king penguins. Perhaps this behaviour along with their larger size got them the name 'emperor'. Compared to other penguins, the 'rock-hoppers' are silly looking birds, with their puffed cheeks and tufts of feathers on either side of their head, and look half scared and half impish. They are very aggressive birds. When other penguins try to disturb them from their nests, they attack fiercely.

Very little is known about the migration of penguins. However the migration of adelic (*Pygoscelis adeliae*) penguin (Fig. 1b) has been studied. They are known to migrate upto 1920 km. They travel almost straight across a featureless landscape and are believed to be aided by a

'clock' and 'compass' mechanism working in combination. They travel 3.2 km-4.8 km per hour and the fastest one may even travel 12.8 km per hour. Moving in a line, a long journey made both through water and on ice, they may take two full weeks to cover upto 160 km. When they finally reach their goal, the long lines of penguins break-up and each male immediately stakes out his claim for a piece of land to build his nest. Then he selects a female who usually remains faithful to him.

Unlike many other species of birds, penguins have been relatively less hunted by man. This is mainly due to the fact that their natural habitat is much more inaccessible than the breeding and living areas of birds that have been hunted to the verge of extinction. The situation may change if the present plans of many countries to establish mining centres on the Antarctica are realized. Even the few penguins which migrate to places near human habitation find life most insecure. The continued existence of penguins as a friendly and amusing birds of the Antarctic thus depends largely on whether man will leave them to themselves, alone on the Antarctic.

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Revolving numbers and revolving pairs

THE term revolving number was first used by the famous Indian mathematician Shakuntala Devi for the number 142857 because any multiple from 1 to 6 of this number is obtained by revolving the number

142857 itself. For example,

$$142857 \times 1 = 142857$$

$$142857 \times 2 = 285714$$

$$142857 \times 3 = 428571, \text{ etc.}$$

But 142857 is not unique in this

SCIENCE FOR THE YOUNG

revolving property though it is the smallest revolving number known. It also has a drawback in that the revolving property is not exhibited when multiplied by 7.

Other revolving numbers found by author with the help of a calculator by trial and error and adjustments are very big numbers necessitating laborious multiplications but the results are fascinating—the digits always re-appearing one after another as if from a magic box in a perfect continuous anticyclic order without any break.

Consider the 16 digits number 1176470588235294 = Say X for convenience. Now,

$$\begin{aligned} X \times 1 &= 1176470588235294 \\ X \times 2 &= 2352941176470588 \\ X \times 3 &= 3529411764705882 \\ X \times 4 &= 4705882352941176 \\ X \times 5 &= 5882352941176470 \\ X \times 6 &= 7058823529411764 \\ X \times 7 &= 8235294117647058 \\ X \times 8 &= 9411764705882352 \\ X \times 9 &= 1,0588235294117646 \end{aligned}$$

The last one is a 17 digit number. If we convert it into 16 digits by adding the first digit from left (i.e. 1) to the rest, for example, if we add 1 to 0588235294117646, we get 0588235294117647. All the multiples of X when converted to 16 digits is a revolving form of X itself.

Again consider any number obtained by revolving X such as 6470588235294117 = Say X_1 for convenience. Now,

$$\begin{aligned} X_1 \times 1 &= 6470588235294117 \\ X_1 \times 2 &= 1,2941176470588234 \\ &\quad \rightarrow 2941176470588235 \\ X_1 \times 3 &= 1,9411764705882351 \\ &\quad \rightarrow 9411764705882352 \\ X_1 \times 4 &= 2,5882352941176468 \\ &\quad \rightarrow 5882352941176470 \\ X_1 \times 5 &= 3,2352941176470585 \\ &\quad \rightarrow 2352941176470588 \end{aligned}$$

$$\begin{aligned} X_1 \times 6 &= 3,8823529411764702 \\ &\quad \rightarrow 8823529411764705 \\ X_1 \times 7 &= 4,5294117647058819 \\ &\quad \rightarrow 5294117647058823 \\ X_1 \times 8 &= 5,1764705882352936 \\ &\quad \rightarrow 1764705882352941 \\ X_1 \times 9 &= 5,8235294117647053 \\ &\quad \rightarrow 8235294117647058 \end{aligned}$$

Similarly, all the other revolving forms of X can be shown to have the same property.

Or consider the 18 digit number 1052631578944736842 = Say Y. Now,

$$\begin{aligned} Y \times 1 &= 105263157894736842 \\ Y \times 2 &= 210526315789473684 \\ Y \times 3 &= 315789473684210526 \\ Y \times 4 &= 421052631578947368 \\ Y \times 5 &= 526315789473684210 \\ Y \times 6 &= 631578947368421052 \\ Y \times 7 &= 736842105263157894 \\ Y \times 8 &= 842105263157894736 \\ Y \times 9 &= 947368421052631578 \end{aligned}$$

Again consider any number obtained by revolving Y, say 789473684210526315 and call it Y_1 for convenience. Now,

$$\begin{aligned} Y_1 \times 1 &= 789473684210526315 \\ Y_1 \times 2 &= 1,578947368421052630 \end{aligned}$$

and converting to 18 digits

$$\begin{aligned} &\rightarrow 578947368421052631 \\ Y_1 \times 3 &= 2,368421052631578945 \\ &\quad \rightarrow 368421052631578947 \\ Y_1 \times 4 &= 3,157894736842105260 \\ &\quad \rightarrow 157894736842105263 \\ Y_1 \times 5 &= 3,947368421052631575 \\ &\quad \rightarrow 947368421052631578 \\ Y_1 \times 6 &= 4,736842105263157890 \\ &\quad \rightarrow 736842105263157894 \\ Y_1 \times 7 &= 5,526315789473684205 \\ &\quad \rightarrow 526315789473684210 \\ Y_1 \times 8 &= 6,315789473684210520 \\ &\quad \rightarrow 315789473684210526 \\ Y_1 \times 9 &= 7,105263157894736835 \\ &\quad \rightarrow 105263157894736842 \end{aligned}$$

All the other revolving forms of Y have the same property which can be easily verified.

Such numbers as X or Y above are pure revolving numbers of which 142857 is the smallest known. There is another type of revolving numbers which come in pairs and can be termed as revolving pairs. Consider the pair 153846 and 230769 Say P_1 and P_2 for convenience.

$P_1 \times 1 = 153846$, $P_1 \times 2 = 307692$ which is a revolving form of P_2 . $P_2 \times 1 = 230769$, $P_2 \times 2 = 461538$ which is a revolving form of P_1 .

$$\begin{aligned} P_1 \times 3 &= 461538, P_2 \times 3 = 692307 \\ P_1 \times 4 &= 615384, P_2 \times 4 = 923076 \\ P_1 \times 5 &= 769230, P_2 \times 5 = \\ &\quad 1,153845 \\ &\quad \rightarrow 153846 \end{aligned}$$

(converting to 6 digits)

$$\begin{aligned} P_1 \times 6 &= 923076 \\ P_2 \times 6 &= 1,384614 \\ &\quad \rightarrow 384615 \end{aligned}$$

$$P_1 \times 7 = 1,076922$$

$$\rightarrow 076923$$

$$\begin{aligned} P_2 \times 7 &= 1,615383 \\ &\quad \rightarrow 615384 \end{aligned}$$

$$\begin{aligned} P_1 \times 8 &= 1,230768 \\ &\quad \rightarrow 230769 \end{aligned}$$

$$\begin{aligned} P_2 \times 8 &= 1,846152 \\ &\quad \rightarrow 846153 \end{aligned}$$

$$\begin{aligned} P_1 \times 9 &= 1,384614 \\ &\quad \rightarrow 384615 \end{aligned}$$

$$\begin{aligned} P_2 \times 9 &= 2,076921 \\ &\quad \rightarrow 076923 \end{aligned}$$

So we see that any multiple of P_1 or P_2 when converted into 6 digits is a revolving form of either P_1 or P_2 . Also, for any particular multiple of P_1 and P_2 , one is a revolving form of P_1 and the other of P_2 .

Another revolving pair is 129032258064516 and

193548387096774 which can be verified with a little labour.

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Science quiz (Biology)

FOR twenty-six questions given in this quiz, give appropriate answers in one or two words in an alphabetical sequence :

1. A plant whose name is similar to a bone.
2. A name of a place in Australia from where a team of English naturalists made huge collections of plants during a voyage in 1768.
3. A disease allied to haemophilia caused by hereditary deficiency of clotting factor IX.
4. A plant economically important as a stimulant improving the tone and rhythm of heart beat.
5. A name of the ship in which Sir Joseph Banks, an English botanist and a Fellow of the Royal Society of London made explorations of South Sea Islands.
6. An Italian anatomist and a teacher of William Harvey, whose observations indicated

- the presence of valves in veins.
7. A living fossil with bilobed leaves belonging to gymnosperms.
 8. It is the botanical name of plant yielding rubber.
 9. A protein effective against most viruses.
 10. A part of the small intestine lying between duodenum and ileum.
 11. A person with XXY sex chromosomes appearing to be male, but with large breast, small genitalia, atrophied testes and is sterile.
 12. The flower associated with Indian National Film Award.
 13. The five bones of the hand lying between the wrist and the fingers.
 14. A large meat eating plant commonly found in Assam.
 15. A large naked, immovable, female egg of an alga.
 16. A disease of infants thought to be resulting from mercury poisoning.

17. An ecological term relating to limited sample area from which total plant count are made.
18. A largest sized flower pollinated by elephants.
19. A plant having a name similar to a country.
20. A plant having salt excreting glands.
21. A pyrimidine base not found in deoxyribonucleic acid.
22. A flying mammal which feeds on the blood of living animals and men.
23. A smallest angiospermic plant.
24. A pupil of mathematician Pythagoras who identified fossils of water animals and gave the proof that mountains were at one time under water.
25. An illness, caused by arbovirus and spread by a mosquito, not found in India.
26. A famous book written by Erasmus Darwin, grandfather of Charles Darwin.

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(Ans. to quiz on page 497)

THERMONUCLEAR POWER (Continued from page 452)

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11. Tonks, L., *Phy. Rev.*, Vol, 56, p. 360, (1939).

NEUROLOGICAL ENDOCRINOLOGY (Continued from page 447)

order of neuroendocrine reflex there are such chains of endocrine organs between the central nervous system and the target organs. The significance may lie in the amplifying capacity of endocrine organs coupled in series, in which each puts out a consecutively stronger signal. The last one is adequate to arouse the final target organ to change from a quiescent to an active state. The possibility of feedback mechanisms existing at similar levels is also noted. Fig. 5 illustrates, by a way of

summary, the various possibilities of hormonal integration within an organism.

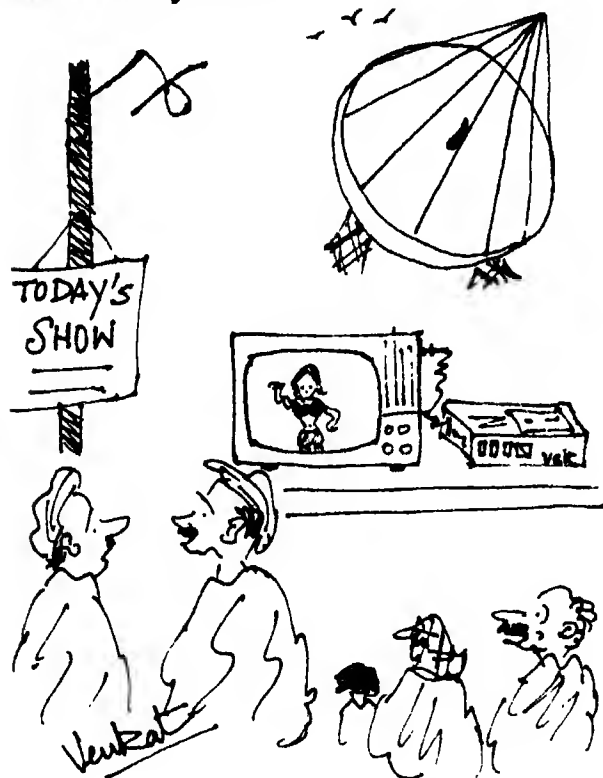
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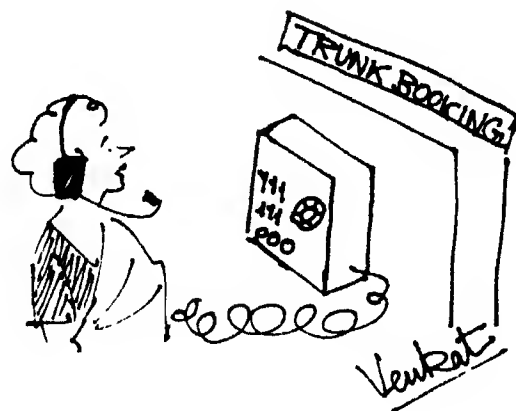
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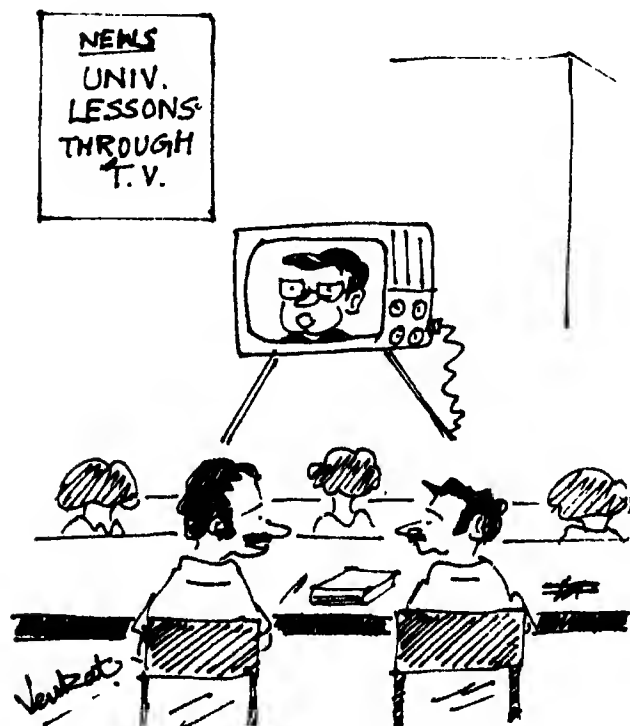
Cartoons by Venkat



"We disconnected the antenna long ago. Now we have our own village VCR"



"Sorry, Sir. If it is Antarctica we can help. But Ambala would be difficult."



"What sort of lecture is this! No cat-calls, no paper planes, no proxies."

NOW

-----?

ACID RAINS
AFFECT
MINOR
ORGANISMS

5 HELD
FOR
THROWING
RAIN WATER
BOTTLES

Venkat



FOR HER

Kerosene wick stoves —A comparative study

FUELS used for cooking depend on their availability, costs, convenience, economy and efficiency. The major domestic fuels used for cooking are firewood, charcoal, cattle dung, kerosene, gas and electricity. Of these, kerosene is the most common fuel used both by urban and rural homemakers.

L. Phadnis and M. Kango (1970) of University of Udaipur reported that 21 per cent of homemakers in Udaipur used kerosene, while 50 per cent and 3 per cent used gas and charcoal respectively for cooking. S. Saundararaj (1973) of Queen Mary's College, Madras, pointed out that kerosene is commonly used in India because it is cheap and convenient to use. Study conducted by S. Das (1968) of Madras University, revealed that 30 per cent to 52 per cent of homemakers felt that kerosene was easy to light, economical and convenient to handle.

However, National Council of Research in India (1959) reported that out of 242 answers, only a few favoured kerosene because of cheapness, but exclusive use of kerosene was thought to be expensive by the majority.

A number of kerosene stoves are

available in market; selection of a stove is based on its efficiency and ease of operation and safety. Wick stoves are safe to use and easy to operate. However the efficiency may vary with the amount of kerosene and number of wicks. Results of the experiment conducted by P.R. Sumangala (1978) of Bangalore University indicated that efficiency of kerosene was higher than kerosas stove when wick stove was used. Though kerosas stove cooked dhal and rice in a shorter time, it was found to be less economical as fuel consumption was high. Efficiency of a fuel varies with the nature of the appliances used and their relative sizes (W. Francis, 1965 from London).

Our study was undertaken with the following objectives :

1. To study heating time of selected kerosene heating appliances.
2. To study the effect of types of wicks on economy and efficiency of kerosene.
3. To study the relation of kerosene amount and length of heating time.

Three different types of kerosene stoves having 10 and 15 round wicks and 4 flat wicks with the tank capacity of 1 litre (10 wicks and 4 wicks stove) and 2 litres (15 wicks stove) available in the local market were used for the study.

The effect of selected kerosene heating appliances on heating time was assessed by heating one and a

half litres of tap water to 95°C in a covered aluminium vessel. The initial water temperature and the amount of kerosene in the stove was kept constant (28°C, and 1 bottle of kerosene). Heating time of water was recorded in minutes and seconds by using a stop clock. This was repeated three times.

To determine the effect of number of wicks on efficiency of kerosene and relation of kerosene amount to length of heating time, half bottle of kerosene (390 ml) and one bottle of kerosene were burnt in the selected stoves till the quantity was exhausted. Length of heating time was recorded when the stove put off by itself. This was repeated three times.

Results

Results obtained from the study to find the effect of selected kerosene heating appliances on heating time are presented in Table 1.

It is obvious from Table 1 that the selected kerosene heating appliances, namely, 10 wicks, 15 wicks and 4 wicks stoves have affected the heating time of water. According to the observation, time needed to heat water from initial temperature 28°C to 95°C increased as the number of wicks in the stove decreased. Fifteen wicks stove was found to be more efficient as the average heating time was 9 minutes 26 seconds as compared to 10 to 4 wicks stoves requiring 10 minutes 4

Table 1. Time required to heat water upto 95°C with one bottle of kerosene

Replicate	Initial water temperature in °C	Stoves					
		10 wicks stove		15 wicks stove		Flat 4 wicks stove	
		Mts	Sec.	Mts	Sec.	Mts	Sec.
1	28°C	9	56	8	51	10	20
2	28°C	9	44	8	55	11	51
3	28°C	10	33	8	56	11	00
Total	28°C	30	13	26	42	33	11
Mean		10	04	9	26	11	03

Table 2. Time required to burn half a bottle and one bottle of kerosene completely

Repl- icate	Stoves											
	10 wicks stove				15 wicks stove				Flat 4 wicks stove			
	Half bottle		One bottle		Half bottle		One bottle		Half bottle		One bottle	
	Mts	Sec.	Mts	Sec.	Mts	Sec.	Mts	Sec.	Mts	Sec.	Mts	Sec.
1	131	17	270	23	103	08	157	37	160	44	277	30
2	123	35	270	37	105	13	156	56	150	10	270	15
3	130	21	275	25	107	25	168	51	145	17	270	10
Total	385	13	816	25	315	46	483	24	456	71	817	55
Mean	128	37	272	08	105	15	161	08	152	03	272	51

seconds and 11 minutes 3 seconds respectively.

It is evident that the number and type of wicks affect efficiency in terms of time consumption. Results of this experiment find some similarity with the opinion of W. Francis (1965, London); "efficiency of a fuel varied with the nature of the appliances used and their relative sizes".

Stove with 15 wicks was found to be the least efficient as kerosene consumption was the highest when measured in terms of the number of hours burn'. When half a bottle of kerosene (390 ml) was used, flat 4 wicks stove was the most efficient since it could be used for 152 minutes 3 seconds; however, when one bottle of kerosene was used not much difference was observed in the effi-

ciency of the two stoves. Efficiency of each stove increased with the increased amount of kerosene in the tank. Efficiency of 10 wicks stove increased more than double the efficiency of flat 4 wicks stove. Increase in efficiency was the least in case of 15 wicks stove.

Results of the experiment indicate that the number and type of wicks play an important role in efficiency of the fuel, that is, in terms of time consumption.

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FOR HER to be inactive due to the absence of one essential amino acid. But the addition of fish in human diet provides an excellent source of all essential amino acids.

Recent nutritional studies have established that at least one third of the total requirement of protein in daily diet must come from animal source. Fish provides 80% of the animal protein consumed in our country. It is particularly valuable for providing proteins of high quality comparable with those of meat, milk or eggs. Fish proteins tend to be higher in lysine and lower in tryptophan content than those of meat.

Apart from the quality, fish also constitutes a good source of proteins quantitatively. The edible portion of freshwater and estuarine fish contains about 14% to 25% protein. Marine fish contains protein from 9% to 26%.

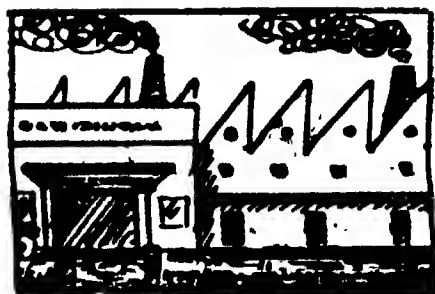
Different species of fish vary in regard to percentage of proteins, fats, minerals and vitamins. There are species of freshwater fish which contain as low as 0.6% fat. Such fishes are useful where a low-fat, high protein diet is recommended. On the other hand, most fishes contain higher proportions of fat. Fish oil has generally more unsaturated fatty acids than animal fats. Since polyunsaturated fatty acids keep down cholesterol level of blood, fish and
(Continued on page 497)

Fish : an integrated source of human nutrition

CEREAL grains supply 70%-80% of the total protein consumed by the population in developing countries. It is not ideal because cereal proteins are generally deficient in one or more of the essential amino acids. For example, rice is deficient in lysine and threonine, wheat lacks in lysine, and corn is deficient in lysine and tryptophan. In such cases, the rest of the essential amino acids tend

Table 1. Average mineral and vitamin content of fish (edible part)

Mineral	Quantity (mg %)	Vitamin	Quantity (µg %)
Potassium	300	Vitamin A	25 (microgram)
Chloride	200	B-Vitamins	50
Phosphorus	200	Thiamine	50
Sulphur	200	Riboflavin	120
Sodium	63	Nicotinic acid	3 mg %
Magnesium	25	Vitamin B ₁₂	1
Calcium	15	Pantothenic acid	0.5 mg %
Iron	15	Pyridoxine	500
Manganese	1.0	Biotin	5
Zinc	1.0	Folic acid	80
Fluorine	0.5	Vitamin C	3 mg %
Arsenic	0.4	Vitamin D	15
Copper	0.1	Vitamin E	12
Iodine	0.1		



SCIENCE IN INDUSTRY

Low-cost solar cooker

EIGHTY per cent of the Indian population living in villages uses fire wood and cowdung as fuel for cooking. Cowdung burning is hazardous to health due to the smoke containing benzo-pyrene, a cancer promoting chemical. By burning, cowdung nitrogen rich manure which is so essential to our cultivation is reduced to ashes.

It is the need of the day that we think of some alternate source of energy to save our precious jungles and cowdung-manure. The most sensible alternative appears to be the solar energy. Fortunately, we have abundant sunshine. Figures for insolation in a few cities, indicate that solar energy can be fruitfully utilised atleast for 8 months in India when the sky is clear (Table 2).

Realising the urgency of relieving strain on the conventional fuel, and attracting the public attention towards the use of solar energy, the State and Central Governments have declared a subsidy of Rs. 150/- on solar cookers. These cookers are ready for sale in big cities. In spite of the subsidy, the price of a really efficient solar cooker comes to about Rs. 450/-. This is a big amount for a lower middle class family and is beyond reach for the poor villager who actually needs it. These cookers use a double glass lid and a mirror of about

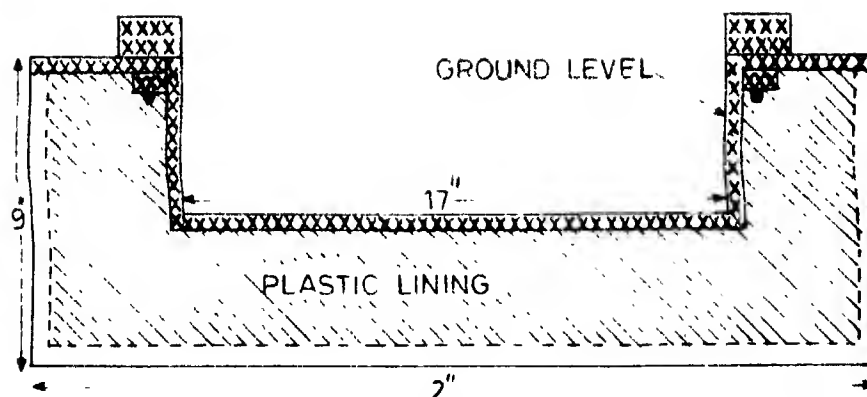


Fig. 1

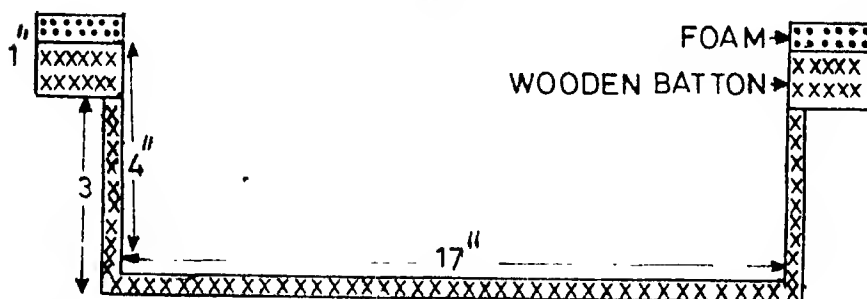


Fig. 2

50 cm × 50 cm size. These parts of the cooker are fragile and not suitable for rough handling. Moreover, in order to make the cookers compact all the parts are hinged together making the whole assembly very heavy and inconvenient for a housewife to lift it single handed.

It appears that due to the weight, the prohibitive price and the fragile parts of the cookers available in the market, though efficient, they would not be acceptable to the rural poor.

Parts of low cost solar cooker

During the course of a project on solar energy utilisation as an outcome of our efforts to devise a low cost solar cooker, we have designed a solar cooker which is as efficient as the conventional box type cooker. Its cost is nominal and the parts are all separate. It is easy to operate and handle. The cooker has the following four parts :

(1) A pit in the ground, of size

Table 1. Direct solar radiation on horizontal surface (clear sky condition)

	Ahmedabad	Akola	Bangalore	Nagpur	Delhi
Jan	0.632	0.662	0.774	0.654	0.564
Feb	0.710	0.737	0.834	0.725	0.653
March	0.777	0.783	0.876	0.778	0.750
April	0.791	0.797	0.859	0.796	0.775
May	0.794	0.799	0.818	0.799	0.792
June	0.772	0.747	0.791	0.747	0.753
July	0.768	0.747	0.797	0.745	0.736
Aug.	0.768	0.772	0.820	0.769	0.711
Sept.	0.745	0.771	0.815	0.766	0.693
Oct	0.726	0.751	0.851	0.742	0.579
Nov.	0.670	0.691	0.796	0.685	0.579
Dec	0.613	0.647	0.761	0.641	0.531

(KW per square meter)

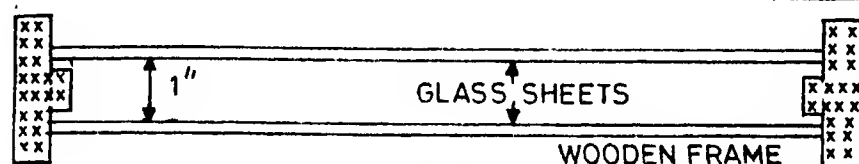


Fig. 3

60 cm \times 60 cm \times 23 cm. The pit is filled with rice-husk or wood dust or small one inch pieces of coconut husk (Fig. 1).

(2) Tin tray of size 45 cm \times 45 cm and height 10 cm blackened within and fitted with four 2.5 cm \times 2.5 cm wooden batons on the brim (Fig. 2). Foam strips are pasted on the upper sides of the batons.

(3) Double glass frame of size slightly bigger than the tray, with 2.5 cm separation between the two glasses; (Instead of two glasses, one can use one glass and one thick, transparent, plastic sheet).

(4) Silver paper pasted on the twin planks, hinged together to stand erect at right angles to each other, each of size 50 cm \times 50 cm (Fig. 4). If aluminised polyester sheet is available, more reflectivity can be achieved.

Preparation of the pit

The pit or the raised brick square is prepared at a place in the courtyard where sunshine is available from morning till evening. The pit is lined with waste plastic sheets from all sides within and then dry, bad conducting material is packed in it. The blackened tray is then embedded at the centre keeping the wooden batons slightly above the packing material. If aluminised polyester sheet is available, it is pasted on the outer sides and below the tray before embedding it in the pit. The waste plastic sheets are then spread on the packing and are covered by cowdung or mud and the pit is levelled to the ground. Now only the tray is seen. When not in use, the tray may be covered by a plank.

Adjustment for cooking

Glass lid is just put on the tray at about 8 O'clock in the morning. As the upper side of the tray is covered with foam and the glass frame is bigger than the size of the tray, the assembly becomes air-tight. The twin reflectors are then placed by the side of the tray so that maximum sunshine is reflected on the glass lid and enters the tray. In about half an hour the inside temperature reaches 100°C. on a clear day.

The food to be cooked is taken with just enough water in flat aluminium containers (8 cm in height) with fitting lids, and blackened from outside. At a time four containers can be accommodated. The containers are kept in the tray. The glass lid is again placed in position immediately.

Time and temperature achieved

In summer, food for a family of 6 can be cooked in 100 minutes, i.e., if the food is kept at 8.30 A.M. in the cooker, the meals are ready by 10.10 A.M. In summer the temperature in the tray may at times reach 200°C. In one experiment cooker was covered by glass lid at 8 A.M. in the morning, the temperature reached 130°C, at 13.30 hours reached 240°C, and at 15.00 hours it decreased to 130°C. indicating that the cooker can be used for about 7 hours and three meals can be cooked in one day.

Cost of the cooker

1. The tray can be prepared by local tin maker from old cans

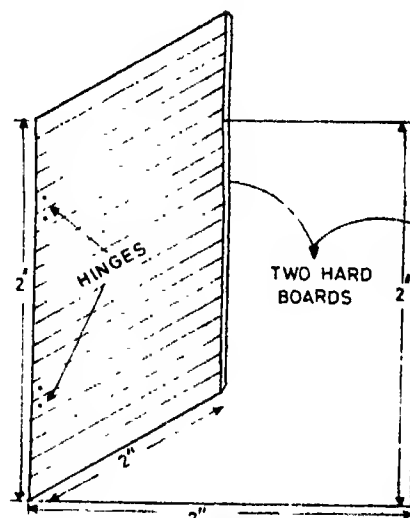


Fig. 4

Approximate cost Rs. 15.00

2. Double glass lid : Two ordinary photo-frame glasses fitted on either sides of a wooden frame .. Rs. 30.00
 3. Twin reflectors—Two hard board pieces, wooden batons and silver paper .. Rs. 20.00
 4. Nails, paint, etc. .. Rs. 15.00
- Total : Rs. 80.00

The cost of the cooker without containers comes to Rs. 80/- only.

It is hoped that due to the low cost and less skilled labour needed, this design of the solar cooker will be popular in the rural sector where sufficient open space is available around homes.

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SCIENCE SPECTRUM (Continued from page 482)

(1982), C.L.Y. 451 (Swedish Supreme court)

7. R.V. Okorodo (1982), C.L.Y., 590

8. R.V. Wood (1982), C.L.Y., 569

9. Brinkibon V. Stahag. Etc. MBH (1st 82), IAER, 293, HL

P.M. BAKSHI
Member, Law Commission,
New Delhi

ENVIRONMENT

Pesticides pollution in marine environment

IN recent years, the use of pesticides has increased by many folds in many parts of the world. The major cause of pesticidal hazard is faulty application and negligence on the part of the applicator in adopting certain simple precautionary measures. Added to this is the lack of knowledge about proper dosage. Pesticides are economic poisons employed to regulate the impact of various animals and plants upon our life and economy. The effect of vast majority are relatively non-selective and their usage therefore may result in undesirable, even unanticipated, side effects. The use of pesticides has undoubtedly contributed to increased crop yield and to human health, but has also produced a number of adverse effects, including widespread pollution of the natural environment accompanied by damage to marine and inland fisheries, beneficial insects and occasional overt poisoning of humans.

The production of pesticides in India for agricultural development during 1976-80 was about 250,000 tonnes. It can be assumed that 25% of pesticides will finally reach the sea. Such enormous quantities, when added to the seas around India, will undoubtedly have some effect on water quality of marine environment. There are two main groups of synthetic pesticides: (i) organochlorine pesticides and (ii) organophosphate pesticides. Organochlorine compounds such as DDT and BHC are most toxic to fishes. Many of these chemicals are stable and are not metabolized nor excreted to any appreciable degree; they remain stored in tissues. Organophosphorus

compounds, the commonest of which are malathion and parathion, are generally less toxic to fishes. They are relatively unstable and rarely stored to any extent within animals, but are highly toxic to fish food organisms.

A number of pesticides are used in India and demand for them is on increase. It is estimated that there is a 15% increase in the consumption of pesticides every year throughout the world. During the last ten years, the use of DDT alone in India has increased nearly four folds. It is estimated that DDT and BHC requirements during 1985-86 would be about twenty thousand tonnes and ten thousand tonnes respectively, twice the present requirement.

Pesticides may enter aquatic ecosystem indirectly by drift by spraying on agricultural land from fallout from air-dust particle accumulations in the atmosphere, in run off from agricultural lands by direct application to aquatic environment to eradicate mosquitoes, etc., by discharge of industrial waste emanating from a pesticide factory or improper discharge of excess pesticides and containers. Aquatic plants and animals can accumulate certain pesticides in many tissues in greater concentrations than can water. This indicates the biological magnification of these chemicals. Such a biological magnification of pesticides may result in high pesticide concentrations in fishes and birds. Organochlorine insecticides have the greatest magnification because they are persistent and have a high affinity for lipids. The degree of magnification of insecticides is usually proportional to

their persistence and inversely related to their suitability in water. In aqueous system, pesticides encounter volatilization, decomposition by ultraviolet light irradiation, microbial degradation, biological magnification and absorption and desorption from suspended matter. All these phenomena are not sufficient to result in self-purification of water and so additional treatment and disposal methods are required to eradicate pesticides from aquatic environment. DDT, BHC, chlordane, heptachlor, toxaphene, aldrin, dieldrin and endrin are some of the chemicals most toxic to fishes and other biological communities. About 77,420 tonnes of pesticides and insecticides are used in agricultural development purposes in India every year. In view of the imperative need to increase food production, pesticides application within the country will further increase. Field research on the nature and extent of pesticide pollution in marine environment is progressing slowly.

Recent studies have proved that even very low concentrations of pesticides which enter the environment can affect productivity of these waters, kill eggs and larvae of clams and oysters; influence the behaviour of fishes such as schooling and feeding; induce changes in the blood chemistry and enzymatic functions of these organisms; reduce backbonic collagen contents and indirectly interfere with food chains. These pesticides are accumulated more in plants and fatty tissues of fishes. Animals which have become weak and moribund as a result of exposure to pesticides may easily be destroyed by predators. Since very low concentrations of organochlorine pesticides affect reproduction in fishes, there is every possibility that these pollutants may adversely affect the local fishery.

Pesticide-induced mortality patterns of marine molluscs, crustaceans and teleosts are also measurably related to various physio-chemical environmental parameters. They

include temperature, salinity pH of the medium, type and concentration of chemical and duration of exposure. Some of the organophosphorus pesticides for example are most toxic under conditions of comparatively higher temperature, salinity and low pH. On the other hand, some organochlorine pesticides are most toxic at intermediate temperatures when pH is more than 9 or less than 7 over a wide range of salinities. Inter and Intra-species variations in susceptibility to different pesticides are considerable. Age, size, sex, general condition and especially chemical makeup are important in predicting degree of resistance of a species to a specific biocide. There has been an accumulation of vast amount of data on pesticides but we are still unable to define the problem fully or evaluate the permanent effect of these chemicals on aquatic animals and their environment.

Although, direct poisoning is the most obvious influence of pesticides,

indirect harm can result in higher animals by concentration of chemicals in their passage through food chains or by reduction in numbers of important food organisms. It is reported that marine invertebrates can take up pesticides from medium by concentration factors of 70,000 and greater.

The importance of pesticide pollution from the human health point of view is being investigated. Today, there is an urgent need of data on the specific areas of pesticides pollution in seas and estuaries, whether the environmental burden is decreasing or increasing and what the sources of contamination are. The establishment of a continuing monitor system is necessary despite technical difficulties; bioassay of animals offers a reasonable approach to this problem. Various kinds of crustacea that make up the most valuable marine harvests are of course representatives of some groups of animals that pesticides are designed to kill. Particular concern is felt for sedentary animals that are

unable to move away from pollution. The oyster might be particularly susceptible because of its tendency to concentrate and store trace chemicals from the surrounding environment.

Coastal zone receives a vast number of adventitious chemicals including insecticides, herbicides to control marsh plants, synthetic, detergents, factory and domestic wastes and radioactive materials. It is possible, even probable, that some of these chemicals display synergism or antagonism. Therefore, early remedial solution in terms of effective and integrated ecological management of the coastal and estuarine ecosystem is necessary to restore normal conditions.

P. NAMMALWAR
Scientist

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FOR HER (Continued from page 493)

fish oils are likely to be particularly useful.

Fish is also a fairly good source of calcium and phosphorus, particularly small fish which are eaten with bones. It is also a source of iron and of trace elements like copper, iodine, arsenic, etc. Fish has also a fair proportion of B-vitamins apart from being a rich source of vitamins A, D and E. Oil-containing fishes, for example, cod, contain considerable quantities of A, D and E in their liver. Some of the visceral organs contain larger quantities of certain B-vitamins than does the flesh.

Fish can also be preserved for a long time for subsequent consumption. Nutritive value of such processed fish and fish products has been reported to be high. Canning and freezing do not appreciably affect protein value. Salted and sun-dried fish have also a high biological value. Smoking or dehydra-

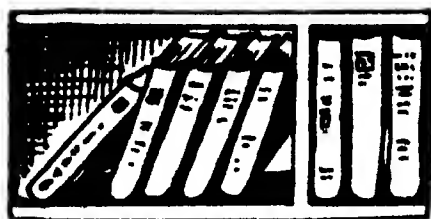
tion at a temperature not higher than 110°F or treatment with cathode rays for sterilization does not significantly affect amino acid composition of fish protein. The calcium content of canned fish is about 200 mg% which reflects its high nutritive value.

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Answers to Science Quiz

- | | |
|----------------------------|------------------|
| 1. Astragalus | 14. Nepenthes |
| 2. Botany Bay | 15. Oosphere |
| 3. Christmas disease | 16. Pink disease |
| 4. Digitalis | 17. Quadrats |
| 5. Endeavour | 18. Rafflesia |
| 6. Fabricius | 19. Salvadora |
| 7. Ginkgo | 20. Tamarix |
| 8. Hevea brasiliensis | 21. Uracil |
| 9. Interferon | 22. Vampire bats |
| 10. Jejunum | 23. Wolffia |
| 11. Klinefelter's syndrome | 24. Xenophanes |
| 12. Lotus | 25. Yellow fever |
| 13. Metacarpals | 26. Zoonomia |



BOOK REVIEWS

THE SPACE MERCHANTS by Frederik Pohl and C.M. Kornbluth, *Penguin Books* (Available From *Penguin Overseas Ltd.*, 706, Eros Apartments, 56, Nehru Place, New Delhi-110 019), Pp. 170, Rs. 31.80.

ADVERTISING is a powerful medium. In fact, the American Industry thinks that it can sell a product provided its advertisement is apt. There is believed to be a whole lot of science behind understanding the taste and thinking of people and the way to exploit it for selling a consumer product. The Science Fiction novel under review has this social science subject as its theme. An advertising company is planning to build a massive advertising campaign to sell Venus, an otherwise hot, hellish planet, as an attractive tourist spot worth a visit for any one. The incharge of the campaign is the hero, Mitchell Courtenay, whose only aim in life, apart from making his campaign a huge success, is to marry a beautiful lady doctor, Kathy. Naturally, when it is a matter of selling a subject such as Venus to the masses huge stakes are involved. Courtenay becomes a victim of a conspiracy hatched by a rival advertising company. The novel traces his adventures when his own identity is destroyed and he is led to live the life of a labourer. But thanks to his ingenuity, he manages to rise up again and reach where he had left. In the process, he however gets a first hand knowledge about the thinking of the masses and an effective way to use it for his advertising campaign for Venus.

The scenarios depicted in the novel are highly realistic in view of the fact that it was written more than 30 years ago. For instance, indus-

trialists are already using the various media to sell their products on a large scale by creating desire for them. Nobody cares two hoot for conservationists, as money has to be made out of every living or non-living thing that is present on earth. Our society has been classified into two classes: one is enjoying all the benefits of science and technology and the other is working like slaves. This novel is acknowledged as a masterpiece in Science Fiction literature. Written in a slick style, the novel however takes time to take hold of the readers' attention.

DILIP M. SALWI

SOLID WASTE MANAGEMENT IN DEVELOPING COUNTRIES by A.D. Bhide and B.B. Sundarasan, *Indian National Scientific Documentation Centre*, 14, Satsang Vihar Marg, New Delhi-110 067, Pp. 222, Rs. 40/-

EVER SINCE Adam threw the first apple core, wastes started accumulating on this planet. But with the increase in population, waste generation has increased with the consequent problem of its disposal. All over the world waste is now being looked at as a resource because it is plentiful, free, flexible and its recycling is possible. It has been estimated that if the garbage potential of Indian cities is fully exploited, a total of 0.63 million tonnes of major nutrients could be diverted to agriculture. If 9000 million litres of sewage could be converted into sullage gas per day from the major cities 20% of their energy requirement could be met. But the major problem is one of waste conversion into useable products after its due collection—both capital intensive exercises. For instance, a 3000 tonnes-per day garbage treatment plant would involve a cost of over Rs. 100 million and providing sewerage facilities and sewage treatment in class I cities would involve an investment of more than Rs. 11,000 million. And we have over 3119 cities!

In the book under review, much stress has been laid on solid waste characteristics, classification and collection. Though these factors are equally important, it is more important to talk about alternatives in waste utilisation methodology. Over 12 million tonnes of flyash is generated from thermal power stations at present and this quantity is going to increase manifold due to greater emphasis on coal as a source of power. This enormous amount is being dumped into lakes and rivers thereby causing pollution. In the west, this ash coupled with sewage is used as a soil conditioner and serves to provide essential micronutrients to the soil. No such technique has been discussed in this book. Capital intensive techniques are available, but it seems that for a country like India cheaper methods need to be evolved.

More research data would have made this volume worthwhile. In its present form the book can only be referred to as a 'solid waste' and only recycling can make it worthwhile.

SUDHIRENDAR SHARMA

METHODS IN INDUSTRIAL MICROBIOLOGY (1983) by B. Sikya, *Ellis Harwood Limited, England (Publishers)*, (Distributors: John Wiley and Sons), Pp. 349, \$ 79.95.

THE book seems to have been written to help biotechnologists understand problems of industrial microbiology. It is an informative book not only for applied microbiologists (who can derive maximum benefit) but also for chemical, mechanical and civil engineers who are concerned with the preparation of designs and manufacture of fermentors and other accessories required by the fermentation industry. The views expressed by the author are broad and comprehensive and the presentation is excellent. The book is divided into ten chapters, each chapter has been provided with relevant references which would be

helpful to those wanting to go into details. The information given is on the designing of fermentors, microbial processes, use of substrates, batch culture, continuous culture, aeration, media sterilisation, improvement, isolation of metabolic products, etc. The problems of strain preservation as well as contaminations during fermentation have been discussed. All microbial processes, leading to the commercial exploitation of the metabolic product, have to start in the laboratory in culture flasks and end up in industrial fermentors. The chapter on culture equipment deals on all the steps of scaling up, from flasks to shakers to laboratory fermentors and then to industrial fermentors. Addresses of various manufacturers of industrial fermentors have been given and descriptions in brief, of some of the fermentors are also mentioned. This book will be useful to those who might be thinking of utilizing applied microbiology for the production of metabolites from microbes useful to human society in various ways, for medicine, agriculture, food or mineralogy.

A.K. MISHRA

MICROBIOLOGICAL APPLICATIONS OF GAS CHROMATOGRAPHY by D.B. Drucker, 1981, Cambridge University Press, Pp. 478, £ 45.00.

CHROMATOGRAPHY could be defined as a technique for chemical separation by partition of a solute between a mobile and a stationary phase, or through selective adsorption onto a solid. The mobile phase, instead of being a liquid, could be a vapour. A gas chromatograph consists of a column containing a solid adsorbent, or a liquid stationary phase, on an inert solid support material. The mobile phase is a carrier gas (usually N_2). In order that the components of a mixture are sufficiently volatile, the temperature of the column is raised by encasing it

in an oven. The samples are injected through a rubber seal. The components pass through the column and are identified through a detector. The signals are amplified and recorded on a chart recorder. The book deals in details with the theory of gas chromatography, ovens and columns, detectors, recorders and integrators, the latter doing the printing out of numerical data of an analysis. The book is divided into seven chapters with literature cited, appearing at the end.

This book shows the ways and means of identification of various microbial activities concerned with the (a) analysis of fermentation products, (b) detection of microorganisms (c) analysis of structural components like lipids, proteins, nucleic acids, polysaccharides, etc., of microorganisms. The chapter on identification of microbes is excellently written and there is information on the identification of microbes in food, cerebrospinal fluids, urine, blood and serum samples. Pyrolysis is the degradation of molecules through heat to produce more volatile substances and smaller molecular weights. A chapter has been devoted to this. Pyrolysis gas liquid chromatography has been applied for planetary investigations, organic analysis of meteorites, forensic science as well as biomedical studies. This book is first of its kind compiling various techniques in detail. It would be very helpful to biologists who are in need of comprehensive information on gas chromatography and like to procure such an instrument for various analyses.

A.K. MISHRA

BICHITRA JEEBJANTU (Strange Animals) by Ajoy Home, Shaibya Prakashan Bibhag, 86/1, Mahatma Gandhi Road, Calcutta-700 009, Pp. 102, Rs. 12.00.

THE animal kingdom is fascinating. Man's association with

animals is age-old. He has domesticated many of them to serve him and has learnt to live amicably with many others. Some of these animals are quite common and they are a part of our daily life. There are others which can be seen only in the zoological parks. Some of them are rare animals found only in distant lands and places. But what keeps some animals apart from the rest is their strange shape or behaviour or unusual breeding or feeding habit. Naturalist Ajoy Home describes thirty-two such animals in this small yet informative book. They cover a wide variety—from the spoon-billed platypus, fiddler crab and the "mountain devil" to the sharp-toothed pirhana, "tiger cat" and the Indian pangolin. The descriptions (in Bangali) are thoroughly lucid. In most cases they are based on the author's own life-long study of the animals and are full of interesting anecdotes. Each chapter has a photograph of the animal and also all the vital details about its habitat, food, breeding habits and so on. The description, though brief, will be useful for identifying the described species. An enjoyable book which would make an ideal companion for any young animal lover.

BIMAN BASU

Books Received

1. **STOVES AND TREES** by Gerald Folley, Patricia Moss and Lloyd Timberlake (Available from : *Earthscan*, 10 Percy Street, London, WIP ODR), Pp. 87, £ 3.50.
2. **GUIDE TO RECORDS RELATING TO SCIENCE AND TECHNOLOGY IN THE NATIONAL ARCHIVES OF INDIA: A RAMP STUDY** by S.A.I. Tirmizi, National Institute of Science, Technology and Development Studies (NISTADS), Hillside Road, New Delhi-110012, Rs. 115.

BOOK REVIEWS

3. BASIC CONCEPTS OF ANALYTICAL CHEMISTRY

by S.M. Khopkar, *Wiley Eastern Limited*, 4835/24, Ansari Road, Daryaganj, New Delhi-110002, Pp. 367. Price not mentioned.

4. FORTRAN CASE STUDIES

(With Computer Printouts of Forty Programs), by R. Ramaswamy *R.R. Computer Centre*, (Orion 8000 Computer system), 25,

Chitrakala Colony, Tirunagar, Madurai-625006, Pp. 54, Rs. 10.

5. ELEMENTS OF BASIC PROGRAMMING

by R. Ramaswamy, *R.R. Computer Centre*, 25, Chitrakala Colony, Tirunagar, Madurai-625006, Rs. 25/-

6. ELEMENTS OF COMPUTER PROGRAMMING

by R.

Ramaswamy, *R.R. Computer Centre*, 25, Chitrakala Colony, Tirunagar, Madurai-625006, Rs. 30/-.

7. ORGANIC BLOOM—AN EVOLUTIONARY HYPOTHESIS

by Reedivari Sarva Jagannadha Reddy, (Available from : R.S.J. Reddy, Department of Zoology, Government Degree College, Nagari-517590, Andhra Pradesh), Pp. 56, Rs. 8/-.

MEDICAL NOTES (Continued from page 485)

Control of blood cholesterol— a new insight

THE intimate association between atherosclerosis (thickening of the artery with deposition of fat on its internal surface) and coronary thrombosis (occlusion by a thrombus of the coronary artery supplying heart muscle) is well established. Occurrence of excess lipoproteins (plasma lipids that include cholesterol in combination with protein) and cholesterol in blood that promotes atherosclerosis is often familial. Incidence of premature atherosclerosis leading to coronary thrombosis is considerably higher in a population which has familial hypercholesterolemia (a familial disease characterized by elevated concentrations of lipoproteins and cholesterol). Pioneering research by Michael J. Brown and Joseph L. Goldstein of the University of Texas, USA, has opened a new direction for control and treatment of hypercholesterolemia.

More than 90 per cent of cholesterol of our body is located inside cells where it is utilised for synthesis of steroid hormones and cell growth. The remaining, less than 10 per cent, circulates in plasma portion of blood

and deposits on the arterial wall leading to atherosclerosis. All the circulating plasma cholesterol is enclosed within lipoprotein particles that are formed from carbohydrates, free fatty acids and triglycerides in the liver and in the small intestine. Some of these lipoproteins are capable of producing fulminating atherosclerosis. The offending lipoproteins are in excess in those who have familial hypercholesterolemia.

A major breakthrough has been achieved by unearthing lipoprotein receptors which exist on surface of liver cells and other tissues. The cholesterol-carrying lipoproteins that circulate in blood form a complex with the lipoprotein receptors. As a result, lipoproteins are taken up in cells and destroyed, while cholesterol is utilised by cells. Binding of lipoproteins with receptors also mediates a process of self-regulation of cholesterol biosynthesis in the body. The increased level of offending lipoproteins in population suffering from familial hypercholesterolemia stems from a genetic defect that hampers production of lipoprotein receptors for removing offending lipoproteins.

This, in turn, offsets autoregulation process of cholesterol biosynthesis. The net result is excess of offending lipoproteins and cholesterol in circulation which deposit on arterial walls and give rise to premature atherosclerosis.

The challenging task of regulating physiologically the level of cholesterol-carrying lipoproteins in blood has been met with success by manipulating production of lipoprotein receptors. Two new drug, Compactin, isolated from a penicillin mold and its analogue menivolin have been discovered. They reduce effectively the level of offending lipoproteins and cholesterol by increasing the production of lipoprotein receptors in liver. Dominance of lipoprotein receptors ensures an efficient cholesterol delivery into cells for physiological purposes due to increased cellular transport of cholesterol. The quantity of lipoprotein receptors which is regulated by genetic and hormonal factors may provide an answer to the important question—Why some individuals do not show increased blood level of lipoproteins and cholesterol despite high dietary intake of fat and cholesterol and *vice versa*.

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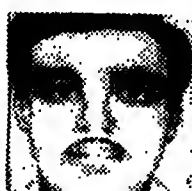
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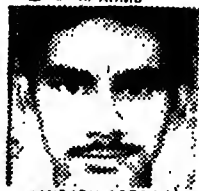


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- While quoting names of scientists, etc., their initials, nationalities and periods of research under reference should invariably be mentioned. **All weights and measures should be given in Metric Units.**
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SCIENCE REPORTER

OCTOBER 1984
VOL. 21 No. 10



Cover : Jupiter as seen by Voyager I

Science Reporter is published monthly. Publications and Information Directorate (CSIR) assumes no responsibility for statements and opinions advanced by contributors and the editorial staff.

Editors: S.P. Ambasta
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Sales & Advt.: G.E. Salpekar
Production: V.S. Chaturvedi

Annual Subscription

Inland: Rs. 10.00
Foreign (By surface mail) \$5.00

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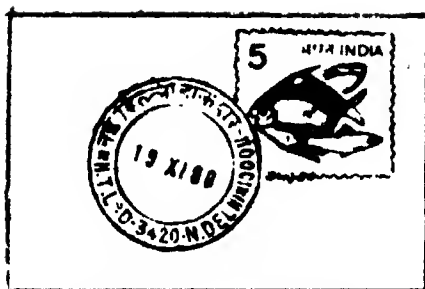
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LETTERS

Jagjit Singh—his writings

Sir, Jagjit Singh in his interview to Dilip M. Salwi (S.R., May-June 1984) has admitted that some people find his writings difficult. From my experience I can say that even scientists find it difficult to comprehend some of his articles, let alone laymen. This, I think, is perhaps due to the fact that Singh prefers to write on frontiers-of-science subjects. Be that as it may, I feel the success of the science writer is not to be too pedantic. He should try to communicate in a language meaningful to masses. Of course, in such a venture the author may not be able to convey much, but whatever little is transmitted is worth the trouble. It is decidedly better than a high dose ricocheting off the cerebrum, rather than being embedded in it. Even if the exposition is down-to-earth, simple and/or repetitive, its information content is not zero as asserted by Singh. The author can see to it that at least some portions register and refresh the memory of the reader, which is quite an achievement. The public too has to realize that however simplified the treatment is it cannot be assimilated without concerted mental effort.

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Pascal

Sir, I enjoyed reading the article **The Helen of Geometry** by C.B.L. Verma (S.R., May-June 1984). The incident concerning Pascal, who, in

an agony of toothache, sought distraction by working on some cycloidal problems and on its abatement interpreted the relief as a divine signal, was particularly interesting.

I would like to state that during the time of Pascal, the growth of science was encouraged by the prevailing protestant belief that man could be saved by doing good work. They believed that the glory of God could be best promoted by the close study of his works. To Robert Boyle, Francis Bacon and their contemporaries, the practice of science was essentially a religious activity.

In this connection it may be relevant to mention that the Charter of the Royal Society ordains that the efforts of the fellows shall be directed "to further promoting by the authority of experiments and the science of natural things and of useful arts, to the glory of God the creator and the advantage of the human race".

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Ringworm fungi

Sir, The article **Ringworm fungi** (S.R., April 1984) by A. Subramanayam was indeed interesting and informative. We would like to add some more information to it.

Keratinomyces is another monotypic form genera included with ringworm fungi. The perfect state of most dermatophytes belong to the family Gymnoascaceae of Ascomycetes which are heterothallic. Hairbaiting technique described by Vanbreuseghem (1952) is usually adopted to study the keratinophilous fungi (fungi attacking keratin containing tissue).

Though often very difficult to locate infection in ordinary light or by microscope, the suspected animals and patients are trapped for examination by following techniques:

(i) The infected hair of suspected pet animals/patients are easily picked out when examined in a darkened room irradiated with "Wood light" i.e.,

ultraviolet light filtered through wood glass (glass containing nickel oxide) under which only the infected hairs give characteristic fluorescence.

(ii) The suspected pet animals/patients are examined by "Hair brush technique" devised by Mackenzie (1963). They are sampled for ringworm fungi by being brushed with sterile toothbrush and the bristles of the toothbrush subsequently pressed on to a suitable agar culture medium.

The infection of child hair by *Microsporum audouinii* may persist for many years but, at puberty however, the infection spontaneously clears due to change in the fatty acids secreted by the scalp, which behaves as fungistatic if not fungicidal for the pathogen. Some dermatophyte infection induces an allergic response away from the site of infection. A ringworm infection of the feet or groin, for example, may lead to the development of sterile lesions, mycides on the hand, face or other parts of the body.

The ringworm fungi of feet and toes is called athlete's foot, an occupational disease of coal miners and professional soldiers. Communal bath leads to the spread of infection by infected skin scale on the floors, from diseased to healthy feet. The infection is aggravated by heavy boots and hard work under humid condition. Ringworm of bread is confined almost exclusively to agricultural workers who contract the disease from infected animals.

Libero Ajello (1960) of United States Public Health Service has discussed the geographical distribution of these fungi of the twenty form-species of which eleven are cosmopolitan; one *T. megninii* is strictly European, *M. nanum* known only from Cuba, and one or two are endemic to Africa. The following form-species are anthrophilic (human origin): *Trycophyton terrestre*, *T. tonsurans*, *T. rubrum*, *T. mentagrophyte*, *T. sulphureum*, *T. violaceum*, *M. audouinii*, *M. Canis*, *T. verrucosum* and *T. persicolor* are common zoophilic (animal origin).

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Allergy

Sir, Re: **Allergy: the imbalance of Immunity** by M.K. Roy Chowdhury (S.R., April 1984), I have a few comments to make.

It was mentioned that allergy is

non-fatal. Intramuscular injection of penicillin may cause death due to anaphylaxis. Drug anaphylaxis and drug allergy are forms of hypersensitivity to drugs. *Aspirin* has no role in the treatment of allergy. Mepyramine maleate, promethazine hydrochloride, chlorpheniramine, maleate etc. are anti-histamines used to treat the condition. Corticosteroids and other drugs which have been mentioned in the article are definitely effective.

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Fibonacci numbers

Sir, Re : **The amazing Fibonacci numbers** by P.K. Mukherjee in S.R., Feb. 1984. The example cited in the article on page 87 (12th line in first column), i.e., if $p=9$ (prime) is wrong, as 9 is not a prime number. Instead, the following examples should have been taken.

(1) If $p = 19$ (prime), $F_p = 4181 = 113 \times 37$ (not a prime),

(2) If $p = 31$ (prime), $F_p = 1346269 = 2417 \times 557$ (not a prime),

(3) If $p = 53$ (prime), $F_p = 53316291173 = 953 \times 55945741$ (not a prime)

I would also like to add the following new properties of Fibonacci numbers :

Every positive integer can be written as a sum of distinct terms from Fibonacci sequence, for example, to represent 50 and 100 we have $50 = 3 + 13 + 34 = F_4 + F_7 + F_9$ and $100 = 3 + 8 + 89 = F_4 + F_6 + F_{11}$

S.S. GUPTA

IRSE (P)

Western Railway
Bombay

In **The amazing Fibonacci numbers** (S.R., Feb. 1984, p. 87) the last line pertaining to Property 10 should read "...if $p=19$ (prime), $F_{19} = 4181 = 37 \times 113$ which is not a prime."

P.K. MUKHERJEE

SHANTI SWARUP BHATNAGAR PRIZE FOR SCIENCE AND TECHNOLOGY FOR THE YEAR 1985

Nominations are invited for the award of Shanti Swarup Bhatnagar Prizes for 1985. The Shanti Swarup Bhatnagar Prize is the highest and most coveted award in Science and Technology in India. This award was instituted in 1957 by the Council of Scientific and Industrial Research in the memory of its first Director and Architect, late Dr. Shanti Swarup Bhatnagar and is made each year for outstanding contributions in Science including Engineering and Technology. The award is for research contributions made primarily in India during the five years preceding the year of the prize. Only Scientists/Technologists who are upto 45 years of age are eligible for consideration.

Five or more Prizes, each of value of Rs. 20,000/- may be awarded annually for notable outstanding research, applied or fundamental, in the following disciplines :

1. Physical Sciences; 2. Chemical Sciences; 3. Biological Sciences; 4. Engineering Sciences; 5. Medical Sciences; 6. Mathematical Sciences; and 7. Other Sciences.

To decide about the Prizes, the Council invites and accepts nominations in prescribed proforma each year from the Presidents of approved Scientific Societies of all-India character, Vice-Chancellors of universities, Deans of Science, Engineering and Technology and Medical Faculties, Directors of IITs, Deans of Faculties and heads of Institutions deemed to be of University status, Director General of major R & D Organisations such as DRDO, ICAR, ICMR; Chairman of AEC, UGC, Space Commission, ONGC; Directors of CSIR Laboratories and BARC, TIFR, and the Bhatnagar Prize Awardees. University Faculties should recommend persons working in their institutions only and route it through their respective Vice-Chancellors while the Faculties in IITs should send their nominations through their Directors. The Directors of CSIR laboratories can nominate a candidate in the discipline of their interest, irrespective of whether they are working in CSIR laboratories or outside. Each Bhatnagar Prize Awardee can send nomination of one person for each year's award in his own discipline only. Each such nomination shall give detailed statement of work and attainments of the nominee, and a critical assessment report (not more than 500 words) bringing out the importance of the significant research and development contributions of the nominee made during 5 years preceding the year of the Prize. Nominations from individuals sponsoring their own names or of others are not accepted.

The nominations may be sent by Registered A. D. Post along with 15 copies of detailed statements of work and attainments of each nominee and the discipline under which the nominee is to be considered. The attainments of the nominee during the past 5 years may be highlighted and sent along with at least one set of reprints of papers published during 5 year period. The nominations, signed by the sponsors, should be marked Confidential and sent to the Deputy Adviser, Extra-Mural Research, CSIR, Rafi Marg, New Delhi-110001 and should reach CSIR latest by 31 March 1985.

The regulations governing the Prize and the proforma for nomination may be obtained from Deputy Adviser, Extra-Mural Research, CSIR, Rafi Marg, New Delhi-110001.

THE MYSTERIOUS GIANT PLANET JUPITER AND THE COMING GALILEO MISSION

AMALENDU BANDYOPADHYAY

The Voyager probes sent back amazing pictures and information about Jupiter and its surroundings. The Galileo spacecraft is likely to make discoveries as yet unimagined

THROUGHOUT history mankind has been concerned with the basic scientific questions associated with the origin of life on earth and any other planet, and the origin of the solar system. Initially the observations were made with the naked eye only. History was made on a July night in 1610 when Galileo observed, for the first time using a telescope, the disk of Saturn. The real nature of the planets gradually began unfolding as more and more powerful telescopes came into being. The launching of the 'Sputnik' in October 1957 ushered in the Space Age. It was not long before missions were directed to the Moon and the neighbouring planets Venus and Mars to make detailed observations to complement the improving quality of earth-based telescopic measurements. But it was not until 1970s that the first missions were directed to the outer solar system and the region of the giant planets Jupiter and Saturn. The initial reconnaissance was made by Pioneer 10 and 11 spacecraft. Then, in 1977, came the launching of two Voyager spacecraft and the start of one of the greatest journeys in the history of space exploration.

Although astronomical research was never intended to be a major

focus of the space programme, it has nevertheless played a significant role in creating the present golden age of astronomy by making possible formerly impossible observations. In the last four years, from the pictures and data sent back by space probes there has been an explosive growth in our knowledge about Jupiter and Saturn and their satellites, rings and surrounding environment. The Voyager mission was a landmark in the history of the exploration of the solar system. This article deals mainly with the recent findings on the giant planet Jupiter.

Earth-based studies

Jupiter, the fifth planet outward from the Sun, is aptly named after the lord of Olympus. Jupiter is the Roman equivalent for the Greek Zeus, chief among the legendary gods, god of moral law and order, protector of suppliants and punisher of guilty. Jupiter reigns supreme as the undisputed head of the planetary family. Except for the Sun, Jupiter dominates the solar system in size, mass, volume and in ability to gravitationally perturb the rest of the family. It is 318 times more massive than the earth; indeed, $2\frac{1}{2}$ times more massive than all of the other planets put together. The solar

system is almost just the partnership of the Sun and Jupiter with the other planets as incidental pieces. But even so, the partnership is unequal. It would take a thousand Jupiters to make up one Sun, although, this is a reflection on our star's bulk rather than on Jupiter's status as the giant of planets. Jupiter's equatorial diameter is 11 times that of the earth though it is $1/10$ th the diameter of the Sun. Its volume could hold 1300 tightly packed earths. Jupiter's density is low compared to the terrestrial planets, only 1.33 times that of water. Jupiter's surface gravity is 2.31 times that of the earth. A person weighing 68kg on earth would tip the scales at 157kg on Jupiter.

Jupiter rotates about an axis inclined only 3° from the vertical (Jupiter's orbit is the horizontal reference) with a period of 9h 55m. It rotates faster than any other planet. A point on its equator travels over 30 times faster than a corresponding point on earth. As a result, Jupiter is very oblate. Its equatorial diameter is 143,900 km while its polar diameter is 134,130 km. The flattening of more than 9700 km represents an oblateness of $1/15$ and is easily discernible in a small telescope.

Jupiter's orbit is nearly circular with

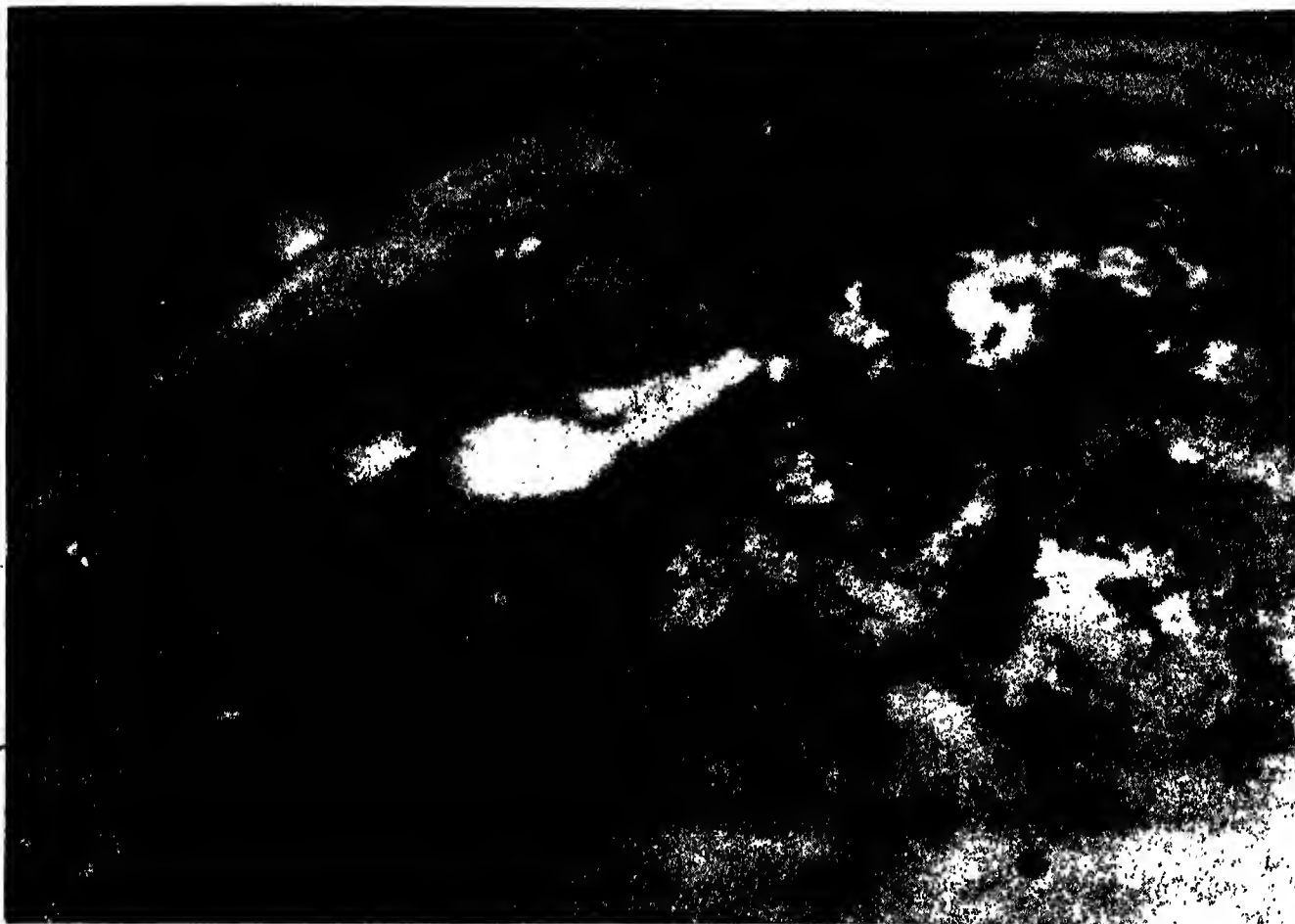


Fig. 1. Voyager 1 photograph of Jupiter. The volcanic eruptions seen in the picture are more powerful than any on earth, and sulphur dioxide gas gives them a blue tinge. Sulphur from the eruption coats itself with reddish sulphur deposits covering any craters that may lie below.

an eccentricity of 0.048. The planet's distance from the Sun varies by 76 million kilometers, the mean distance is 780 million kilometres. Nevertheless, climate variations because of seasonal effects are non-existent on the planet. Jupiter's sidereal period (i.e., the period of its revolution round the Sun) is 11.86 earth-years.

Jupiter is not easy to observe in detail. It is too remote from the earth (607 million kilometres even at the most favourable oppositions). When the solar system formed, the planet found itself with more material than all the other planets combined. Unlike the much smaller earth, which lost its light gases such as hydrogen and helium because its weak gravitational field could not hold back the fast-moving atoms of the two gases, Jupiter has held on its entire original mixture. Most of the planet is com-

posed of hydrogen and helium together with unpleasant hydrogen compounds such as methane and ammonia. The surface which is observed through a telescope from earth is the top of this thick atmosphere.

In a telescope, Jupiter shows up as a yellowish, decidedly flattened globe crossed by streaks known as cloud belts and with other less prominent features such as spots, wisps, and festoons. The most casual is enough to show that it is totally un-earthlike and it has long been known that the surface is not solid, but is made up of gas. Jupiter's surface displays a striking alternation of light zones and dark bands that are parallel to the equator. The dark bands are more or less uniformly gray, although some lighter coloured spots are occasionally seen. The lighter bright zones vary some-

what in colour both in position and in time. They may appear light yellow or again light red and even at times light bluish in cast. Moreover each band and zone rotate about Jupiter's axis at a different rate. The rotation is asymmetrical, that is, speeds in the southern hemisphere are somewhat higher than at corresponding northern hemisphere latitudes.

The most intriguing visible feature of the Jovian atmosphere is the Great Red Spot, first reported in 1831. It might have been seen by the Italian astronomer Cassini in 1660 and used by him in determining Jupiter's rate of rotation. But the first authenticated report dates only to the first third of the 19th century when the Great Red Spot was believed to be a great hollow in the clouds. The spot 48,000 km long and 11,000 km wide is large enough to hold the earth and its moon



Fig. 2. The Voyager 2 image of the region around the Great Red Spot

and the planets Mercury, Venus, Mars and Pluto with room to spare. Scientists are not certain what this Great Red Spot really is. No one knows just what causes the phenomenon. One suggestion is that it is the top of a huge column of heated atmospheric gases that is rising up over some immense surface obstruction.

The spot wanders somewhat from a mean position. One calculation shows that the spot had drifted slowly around the planet, completing at least three revolutions since it was discovered. If this is so, it would be difficult to explain how the spot could be associated with any elevated surface feature. It is also not certain why the spots on Jupiter's surface come in colours—the red is the more tantalizing puzzle. The favourite, though not yet proven, theory is that its colour is due to red phosphorus, the element in match-heads that ignites when a match is struck. Among the poisonous gases in Jupiter's atmosphere there is phosphine, a compound of phosphorus and hydrogen. Phos-

phine may be brought up from the depths in the whirl of a spot and broken down to red phosphorus when it is exposed to the sunlight above Jupiter's cloud layers.

Satellites of Jupiter

Galileo discovered the four largest satellites of Jupiter. They are Io, Europa, Ganymede and Callisto. Their orbits lie within 3° of Jupiter's equatorial plane, close to the ecliptic and in our line of sight. The largest, Ganymede, has a diameter 1.4 times that of our Moon's which makes it larger than the planet Mercury. A good pair of binoculars, steadily supported, will reveal the four largest satellites of Jupiter. They are so large that, if the glare due to Jupiter were not present, they would be visible to the naked eye. Occasionally, a very sharp-eyed observer can see one of them without optical aid when Jupiter is near opposition and when the satellite is near its greatest elongation.

The four large satellites and one

small one form an inner group relatively close to Jupiter—all are less than 2 million kilometres from its centre. As larger and larger telescopes were built and trained on Jupiter, the number of known satellites increased. The thirteenth was added in the 1970s. The four outermost satellites are over 20 million kilometres from the planet and are weakly held by its gravitational field. Oddly enough, these four revolve around Jupiter, in a sense opposite that of all the others. All the satellites beyond the four largest are small; the largest of them has a diameter of roughly 200 km.

Space probes of Jupiter

Till some years ago our knowledge of Jupiter was derived mainly from earth-based telescopic observations which began more than 350 years ago. Modern observations from high-altitude aircraft and orbiting satellites and the wealth of recent findings from interplanetary space probes have revealed some outstanding information about the planet. Between 1973 and 1981, four unmanned probes flew by Jupiter (Pioneer 10 and 11, Voyagers 1 and 2). All of these probes were launched by the NASA (National Aeronautics and Space Administration) of U.S.A. Pioneer 10 was launched in March 1972. It by-passed Jupiter at 132,000 kilometres from the cloud-tops on 3 December 1973. Pioneer 10 received a dose of protons and electrons large enough to kill a human 1000 times over. It was later estimated that, had Pioneer 10 passed only one-half of a radius of Jupiter closer to the planet, it would not have survived. After passing by Jupiter, Pioneer 10 continued to travel away from the sun. Pioneer 11 was launched even before Pioneer 10 reached Jupiter. On 2 December 1974, it raced past Jupiter at a distance of 46,400 km. Although it passed closer to the planet than Pioneer 10, it survived the proton and electron clouds because it was aimed at a latitude of 45° south where these particles are less numerous. The strong gravitational field of Jupiter whipped Pioneer 11 rapidly through the strongest parts of the radiation clouds and up over the northern hem-

isphere. This carefully planned manoeuvre had four benefits: (1) Pioneer could get close to Jupiter and still survive the strongest radiation because of the rapid speed; (2) it could photograph both the south and north poles of the planet, which are not visible from earth; (3) the slingshot effect flipped Pioneer 11 up above the plane of the planets to measure conditions there for the first time; and (4) as planned, Pioneer was retargeted by Jupiter's gravitational force so that it would coast to a 1979 rendezvous with Saturn.

Pioneer 10 and 11 confirmed the idea that Jupiter has a magnetic field and is surrounded by a huge volume of trapped charged particles, chiefly protons and electrons. The Pioneer flybys permitted accurate determination of the masses of the Galilean satellites. The Pioneer flybys confirmed that the planet gives off substantially more energy in the form of heat than it receives from the sun. That is, Jupiter is not just a passive reflector, but has an internal energy source of its own. For this reason, some astronomers have characterized Jupiter as "almost a star", although its mass is at least five times too small for it to generate energy by means of nuclear fusion as real stars do. It has been suggested that the excess radiation produced by Jupiter is simply remnant heat left over from the original condensation of the planet, slowly leaking out through its thick body. The rate at which it escapes from the planet indicates that Jupiter's interior is probably in a turbulent state, with much of the internal heat being carried outward by moving material such as is seen in boiling pots of water.

The next probes, Voyager 1 and Voyager 2 were even more ambitious. They were designed to study both Jupiter and Saturn, while Voyager 2 was scheduled to go on to the outer planets Uranus and Neptune as well. The plan was to send the Voyagers first to Jupiter and then use Jupiter's powerful gravity to swing them round and propel them on towards Saturn. Voyager 2 would then use Saturn's gravity to send it on its way to Uranus

which in turn would then send it out to Neptune. The first Voyager gave trouble in the pre-launch period and eventually was switched with its companion, so that the original Voyager 1 became Voyager 2. Ultimately number 2 was launched first on 20 August 1977 leaving its twin to follow on 5 September. However, Voyager 1 moved in a more economical transfer orbit and during the crossing of the asteroid belt it took the lead, and finally reached Jupiter on 5 March 1979, over four months before its companion. The closest approach of Voyager 1 to Jupiter was 348,890 km and that of Voyager 2, 721,670 km.

The Voyager probes sent back amazing pictures and information about Jupiter and its surroundings. This time the pictures were even better than those from the Pioneers. The vividly coloured belts, zones and spots stood out magnificently and new data were sent back, settling more of the outstanding problems. More important, the existence of more than 32,000 Voyager photographs means that we can at last treat the outer regions of the solar system in the same way as the inner planets: a place where we can deal with hard facts, figures and measurements, rather than disputable and hazy glimpses from our remote station on earth.

Dramatic new photographs returned by Voyager space probes provided more detailed information about the complex atmospheric circulations on the giant planet. They have revealed a varied and continually changing pattern of great complexity. The banded structure of Jupiter was once thought to be relatively stationary, but now movement has been observed between bands—narrow bands have been seen to consolidate and wide bands to come apart. The spotted regions are thought to be Jovian hurricanes, not unlike those on earth, although larger in scale. Hurricanes are caused when rising currents in the atmosphere create low-pressure areas into which gases from surroundings regions flow. Forces generated by the rapid rotation of the planet cause the inflowing gas to swirl

around like whirlpool. A close-up of the Great Red Spot on Jupiter perhaps indicates the ultimate example of a solar system hurricane.

According to the latest information, Jupiter is indeed mainly liquid, 80 per cent of which is hydrogen. Equally amazing are the magnificent photographs of Jupiter's miniature solar system—the Galilean satellites Io, Europa, Ganymede and Callisto. Perhaps the most surprising fact that has been discovered about these satellites is their lack of similarity with each other. Each seems to have its own individual personality. Perhaps the most dramatic discovery is the evidence of active volcanoes on Io. The number of known satellites of Jupiter now total 16.

As the Voyager probes searched closer to the planet, they found that it was surrounded by a system of rings. This was totally unexpected. But Jupiter's rings are quite unlike the rings of Saturn; the former are too dim to be seen from earth. The Jovian system of rings is believed to be no more than a kilometer thick and is composed of dense microscopic particles that extend down to the cloud tops. But where do they come from? That is still a mystery.

Galileo Mission to Jupiter

Voyager gave only brief glimpses of Jupiter. Plans for the Jupiter Orbiter and Probe (JOP) mission were first drawn up at the Jet Propulsion Laboratory and Ames Research Centre of U.S.A. In 1975, more than two years before the launch of the Voyagers. The mission was part of a plan proposed by the Space Science Board of the National Academy of Sciences, U.S.A. After the Voyager flyby probes, the highest priority NASA planetary objective was to be in-depth exploration of Jupiter. Although originally called Jupiter Orbiter and Probe, the programme was soon renamed Project Galileo to honour the Italian astronomer Galileo Galilei who first viewed the four large satellites of Jupiter. Mission planners recognized that the Galileo operation would require both an orbiter and an atmospheric entry probe in order to satisfy all three

major exploration objectives: (i) determination of the chemical composition and physical state of the Jovian atmosphere, (ii) investigation of the chemical composition and physical state of the Jovian satellites, and (iii) investigation of the structure and physical dynamics of the Jovian magnetosphere. These objectives are directly related to the major goals of the NASA planetary exploration programme to further our understanding of the origin and evolution of the solar system, the origin and evolution of life on earth by comparative studies of the other planets.

Why is Jupiter so important? Jupiter rates highest because of all the planets of our solar system its atmospheric composition could be representative of the primordial local solar nebular material. While other bodies evolved and lost material, especially hydrogen and helium, proto-Jupiter's great gravitational attraction held them to it. Because it retains this primordial composition, Jupiter is a better cosmological laboratory than any of the other planets.

Sometime in 1986, one of America's fleet of shuttle launch vehicles will thunder off its Cape Canaveral launch pad into earth orbit. It will carry in its cargo bay the two components of the Galileo mission—an Orbiter and a Probe. After launch from space shuttle the spacecraft will

arrive in the vicinity of Jupiter in a little more than two years. When Galileo is about 150 days and 150 million kilometres from Jupiter, the orbiter will release the Probe. After the Probe is released, the Orbiter will manoeuvre to keep from following the Probe into the planet. Four hours before the Probe mission begins, Galileo will pass within 1000 km of volcanic Io—20 times closer than the Voyager flyby in 1979. This will be the only close flyby of Io during the entire Orbiter mission. Io's gravitational attraction will assist in slowing the Orbiter and permit Jupiter to capture the spacecraft in orbit. This will help determine the composition of Io's surface and the mechanisms by which the Io volcanos feed the torus. The Probe will provide the first direct sampling of Jupiter's atmosphere. Its entire mission will last 60 minutes at most as it descends from the outer fringes to a depth where the pressure is about 10 times the atmospheric surface pressure on earth. Galileo will enter a long looping trajectory about Jupiter with a period of 200 days. The spacecraft's tour through the Jovian system consists of 12 orbits over a period of 20 months.

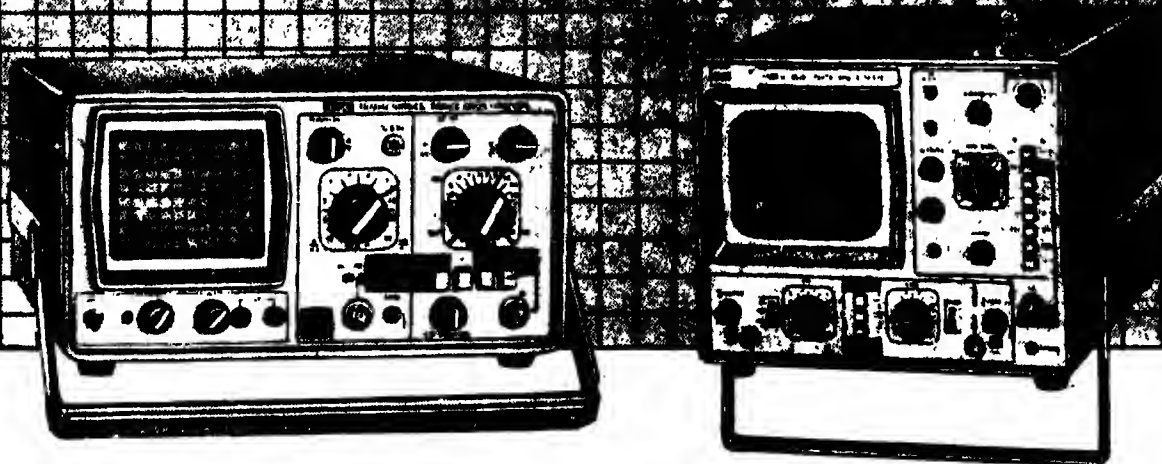
After years of planning, Project Galileo is finally assuming tangible form as numerous laboratories assemble its flight equipment. The first 20 months that Galileo orbits Jupiter will be a time of incredible excitement.

Galileo's Probe also should be able to send back important new information about Jupiter during its short life of about an hour inside its atmosphere. With Galileo the greatest discoveries may be things we have not even thought of.

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*"Why do you deny me water?
Its use is free to all. Nature had
made neither sun nor air nor
waves private property; they
are public gifts"*

Ovid
Metamorphoses

WHY LAW OF THE SEA

K. SATYANARAYANA

ON 10 December 1982, in Montego Bay, Jamaica, representatives of more than a hundred countries signed the United Nations Convention on Law of the Sea, marking the culmination of nine years of concerted efforts of governmental and non-governmental representatives at the United Nations Conference on the Law of the Sea (UNCLOS). This charter, a 'constitution for oceans', with its 320 articles and nine annexes, pertains to every conceivable use of the ocean, namely, exploration and exploitation of renewable and non-renewable resources, conservation and pollution, navigation and overflights, marine research, etc. The convention also draws guidelines for the behaviour of coastal states, defines, maritime zones, lays down rules for drawing boundaries, provides machinery for dispute settlement, etc.

But the central question remains: Why a legal regimen for the sea, especially when more than 70% of earth's surface is covered by the oceans, an area wide enough for every one's use! Within this vast liquid expanse lie inexhaustible amounts of food, minerals and energy (from tides, waves, ocean thermal energy and salinity gradients besides coal, oil and gas). Compelled by the impending depletion of land resources, man looks to the sea in a frantic search for more and more resources to meet the increasing demands of the people. In this pursuit he is prone to destroy the environment either by mismanaging or by overexploitation. It is exactly to counter these vagaries of human nature that the Law of the Sea envisages a systematic and legalised order.

To have a better appreciation of events leading to the signing of the

The Law of The Sea will safeguard every nation's interest in utilisation and distribution of ocean resources and protect the future and well-being of the mankind

Law of the Sea treaty, a brief historical perspective is necessary.

Historical development

From times immemorial the sea has played a significant role in human life. In the quest for expanding his territory, man not only attempted to conquer this endless water mass by navigating, but also tried to appropriate large areas of it for his own varied uses. This has naturally resulted in resistance and opposition from others, leading to conflicts.

Though the origin of the first rule of the Law of the Sea is not known, the law like other areas of international law, seems to have developed from two sources, viz. custom and treaty. The Mauriyan Kings in India (4th century B C) had established the office of Superintendent of Ships to regulate maritime transport and trade. Similarly the ancient Egyptians who engaged in shipping on a wide scale must have had some sort of rule regulating the seafaring activity although there is no such evidence. Rhodes appears to be the birth place of maritime law as indicated by references made in the *Digest* (AD 533). The maritime code of the Eastern Empire (7th or 8th century AD) was called the 'Rhodean Sea Law'. The most widely accepted Sea Law around the 13th century was the *Consolat de mar*

(consulate of the sea) formulated at Barcelona (Spain).

According to traditional Roman Law, seas and seashores were common to all and could be used by any one. This concept known as *res communis* upholds that seas belong to the community. However this concept of freedom of the sea was opposed by powerful nations and they evolved a different concept known as *res nullius*, which supports the view that seas belong to none but are subject to claim. The application of *res nullius* concept became a primary source of conflict which resulted in multilateral treaties and agreements covering navigation, fishing and trading. Spain and Portugal, under the *Treaty of Tordesillas*, claimed sovereignty over most of the seas and could prevent navigation and trading by other nations.

Serious threat to the Spanish-Portuguese hegemony came from the Dutch who resented Portuguese monopoly of the East Indies spices trade. In 1609 Hugo Grotius, a jurist commissioned by the Dutch East India Company, published *Mare liberum*, in which he pleaded for the freedom of high seas for the benefit of all, in a way upholding the concept of *res communis*. He supported fully the Elizabethan theory that the sea belonged to all and is not subject to unilateral appropriation by any nation. John Selden (1635), an Englishman, in reply to *Mare liberum* published *Mare clausum*. He upheld the concept of *res nullius* and advocated that coastal states had the right to appropriate large sections of the sea, maybe to justify the growing British interests at that time in exercising the jurisdiction over waters around Britain. The concept of territorial sea came into existence with the publication of *De comino maris* in 1702 by Bynkershoek. A territorial width of 3 nautical miles (C. 6 km), attributed to a distance of cannon ball shot (though the range of cannon at that time was not more than a single nautical mile), was accepted.

The limits of maritime jurisdiction



Fig. 1. Ship on high seas (Courtesy : Dr. G.S. Roonwal)

have remained a source of conflict between seafaring nations for long. However, two areas of jurisdiction were accepted: (i) territorial sea under the jurisdiction of adjacent coastal states, and (ii) high seas open to all nations with freedom to navigate, fish, lay submarine cables and flyover.

Modern era

Till the 2nd half of 19th century, the seas were used essentially for fishing and navigation. But the scientific and technological advances made subsequently have broadened functional notion regarding the sea and also increased the jurisdiction and political problems. Though it is difficult to demarcate clearly the beginning of the modern era with respect to the Law of the Sea, the following events appear to be the forerunners: (i) failure of the League of Nations codification conference of 1930 to establish a three mile territorial sea and (ii) treaty of Parla between Britain and Venezuela (1942) and Truman Proclamation (1945) leading to juridical claims over parts of the sea-floor. The United States of America under Truman Proclamation claimed control over continental shelf (box p. 514) larger than Alaska and Texas combined, and its resources and fishing conservation rights. Under Santiago Declaration (1954) three Latin American states proclaimed sovereignty over an area of 200 nautical miles.

Keeping in view the controversies and conflicts arising from unilateral

declarations and multilateral treaties, the International Law Commission created by the UN in 1947 was entrusted to codify parts of traditional law and the problems concerning territorial sea. The conservation of resources and the continental shelf were also brought under its purview. As a sequel to this, the UN General Assembly convened the first United Nations Conference on the Law of the Sea (UNCLOS I) at Geneva in 1958. UNCLOS I adopted the following four conventions:

(i) *Territorial sea and contiguous zone.* According to this convention, each state will have control, beyond its land territory and internal waters, to a band or belt of sea adjacent to its coast (territorial sea). The control also extends to the air space above the territorial sea as well as its bed and subsoil. The convention also stipulates sovereignty of a state over a contiguous zone lying seaward from the territorial sea for the purposes of fishing, customs, immigration and sanitation. But the state cannot interfere with the right of innocent passage.

(ii) *Continental shelf.* The coastal states are allowed to exercise sovereign rights over continental shelf (box p. 514) for exploration and exploitation of its natural resources.

(iii) *High seas.* This convention includes all waters outside the national jurisdiction under high seas. They belong to all nations which can enjoy freedom of navigation, overflights, fishing, laying of submarine cables and pipe lines. This con-

vention also includes regulations on piracy and pollution.

(iv) *Fishing and conservation of living resources of high seas*—This remained the bone of contention among nations. The convention provides rights and assigns responsibilities to fishing nations to preserve fish stock. It also provides procedures for resolving disputes in areas where fishing is carried out by more than one nation.

The UNCLOS I failed to agree on limits of territorial sea. Though the convention suggested that the width of the territorial sea and contiguous zone combined should not exceed 12 miles, different states claimed different widths ranging from three miles to over 12 miles. It also failed to define clearly the limits of continental shelf. Though the Second UN Conference on the Law of the Sea (UNCLOS II) was convened in 1960 at Geneva, it failed to resolve these problems.

Around early 1970s it became apparent that the conventions resulting from UNCLOS I and reconsidered subsequently by UNCLOS II were not sufficient to cover various uses of the ocean space in view of the emerging technological advances and socio-political situations, one of the chief causes of concern being the possibility of conflicts arising from the exploitation of minerals (box p. 516) from the deep ocean floor.

The Maltese Ambassador to the UN, Dr. Arvid Pardo, first proposed in 1967 in the UN that the seabed and resources beyond the limits of national jurisdiction be the 'common heritage of mankind', not subjected to appropriation by any nation for its sole use. An appeal was made for an international treaty that would (i) give UN title to seabed beyond present limits of national jurisdiction; (ii) establish an agency to administer marine resources; (iii) allocate revenues from these resources primarily to promote development of poor nations; and (iv) reserve ocean floor exclusively for peaceful purposes in perpetuity. In 1970, while adopting the concept of oceans as 'common heritage', the UN agreed to convene the Third Conference on Law of the Sea (UNCLOS III) to finalise an international sea law treaty that would

Seafloor topography

FOR a better understanding of ocean resources and the sea law, knowledge of the physiography of seafloor is essential. It is broadly classified into 4 major parts, viz. (i) continental shelf, (ii) continental slope, (iii) continental rise, and (iv) abyssal plain (Fig. 2).

Near the continental land mass the sea is generally shallow, and the seafloor gently slopes from the shore to depths of about 200 m. The submerged extension of seafloor is the continental shelf. The continental shelf which covers more than 7% of ocean floor is unequally distributed around the land mass with widths ranging from 1 km to 1500 km. There are many coastal states which are devoid of continental shelf. The gradient of shelf is 1° and its bottom topography resembles that of the adjacent land. For example, if the coastal area

has rugged topography so also would have the continental shelf. Many shelf areas are of special interest in view of the fact that over 80% of the fishery landings of the world are from the continental shelf. The shelf is also increasingly exploited for oil and gas.

The continental shelf terminates seawards at continental edge which is the boundary between continental shelf and the continental slope and is marked by increase in the gradient to 4° . The ending of the continental shelf and the beginning of the continental slope occurs around 50m-500m water depth. The continental slope covers roughly 11% of ocean floor and its gradient varies depending on the locality (sometimes as steep as 45°), and reaching depths of 3000m-6000m. The slope is not even and is fissured by gullies and steep submarine canyons. Both the continental

shelf and the continental slope, referred to as continental margin, are structurally a part of the continents though covered with seawater.

The continental rise at the end of the continental slope shows a gentle gradient and gradually merges with the ocean floor (bottom). Beyond the continental rise are the abyssal plains extending to hundreds of kilometres with slight difference in level and forming nearly 80% of submarine surface of the globe. Its predominant feature is the basaltic bed rock covered by a thin layer of sediment. In some places, the ocean floor rises to form submarine mountains or ridges (2000m-4000m high), and at some other places the ocean floor is furrowed by deep trenches like the Java trench in the Indian Ocean. The deepest of the ocean trenches is the Mariana trench in the Pacific ($> 11,000$ m).

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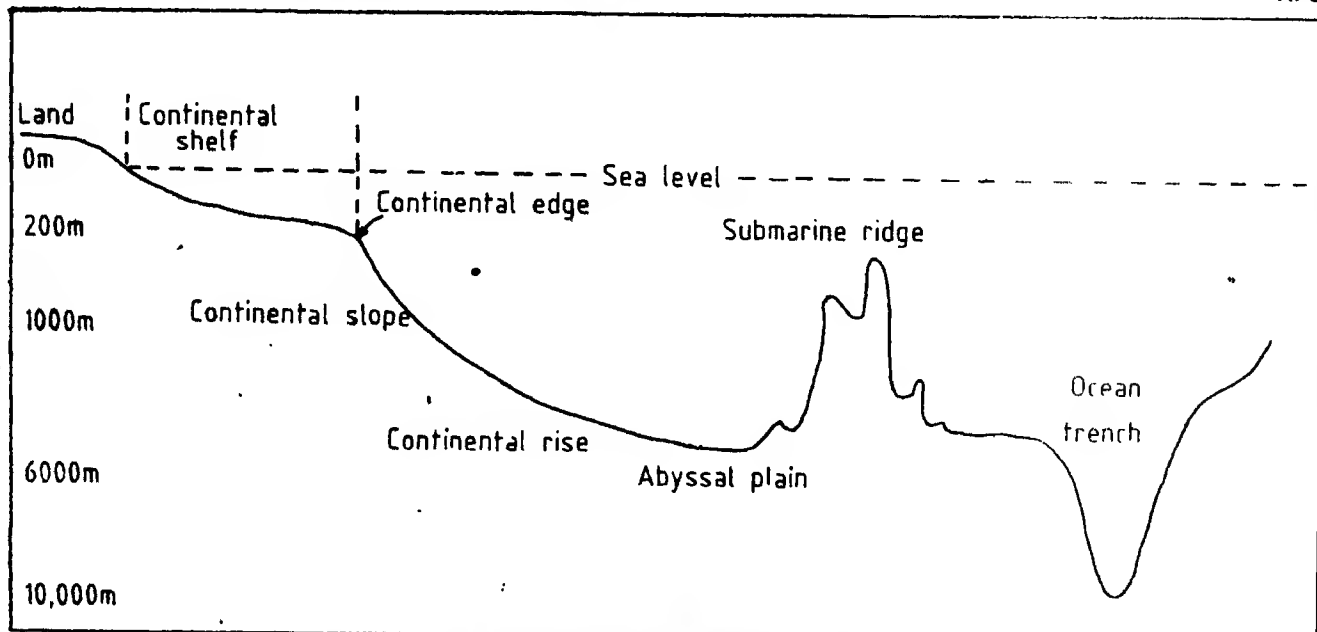


Fig. 2 Bottom topography of the sea

translate this concept into reality.

The first organizational session of UNCLOS III was held in New York in December 1973, followed by sessions at Caracas (1974), Geneva (1975) and New York (1976). At Geneva, UNCLOS III produced a preliminary document, the Single Negotiating Text (SNT), which was subsequently revised (1976). The Revised Single Negotiat-

ing Text (RSNT) became the first attempt by the international community to devise a comprehensive and widely acceptable written constitution for oceans. Finally the convention on Law of the Sea, signed at Montego Bay, replaces the *laissez-faire* system of freedom of seas, with a system of management. Some of the aspects covered under the Conven-

tion are given below:

(1) *Territorial seas and contiguous zones.* The coastal states enjoy sovereign rights over a 12 nautical mile territorial sea (Fig. 3) from their shoreline, and the foreign vessels get the right of innocent passage through these waters for peaceful navigation. Beyond the territorial sea a contiguous zone of 12 nautical miles comes

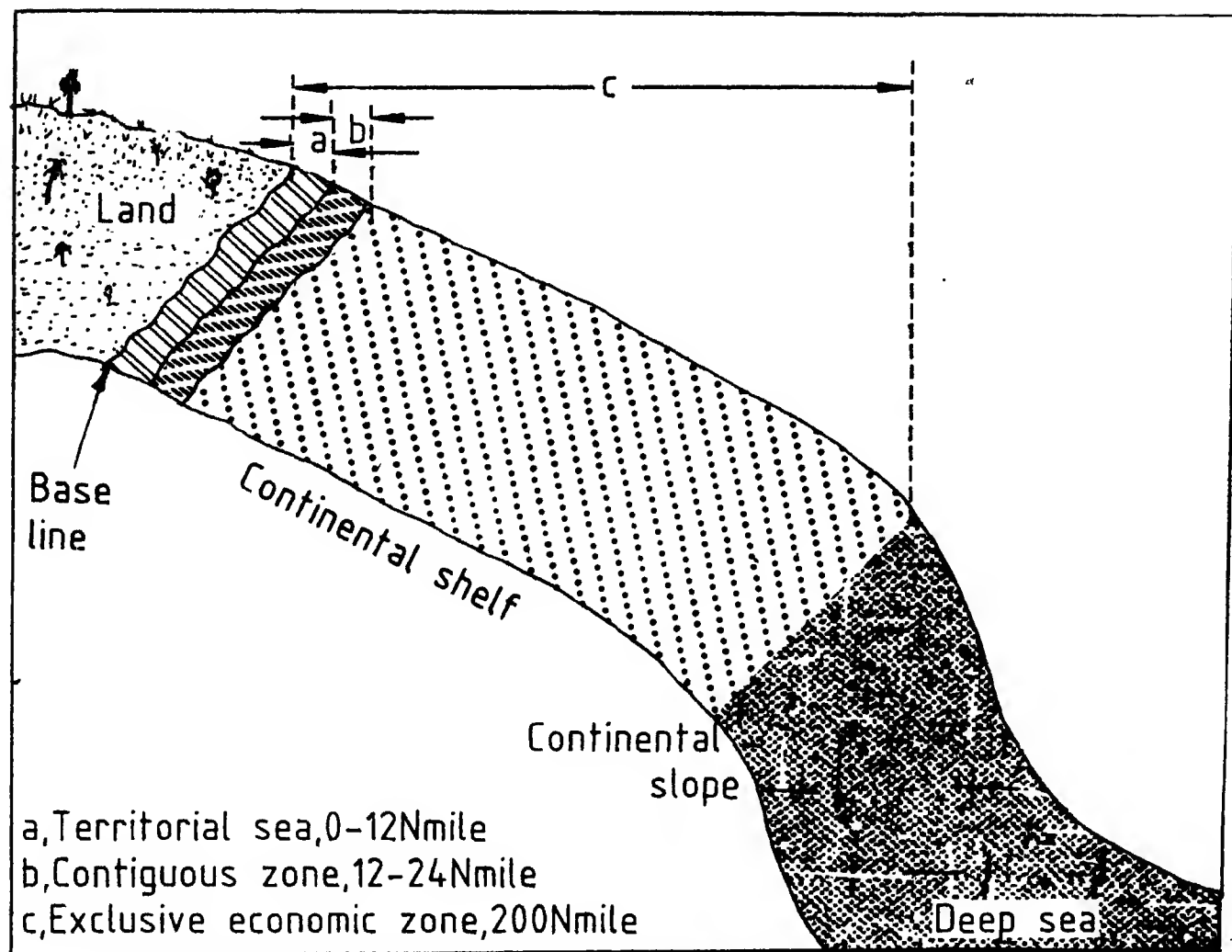


Fig. 3. Zone demarcating the sea as per the convention of 1982 (schematic; distances not to scale)

under the coastal state for the regulation of customs, immigration and scientific matters.

(2) *Straits for navigational purposes.* Under a new concept of 'transit passage' freedom of navigation and free passage through 116 straits around the world are ensured, which cannot be suspended under normal conditions.

(3) *Archipelagic states.* The groups of closely related Islands (Philippines, Indonesia, etc.) and interconnecting waters would have sovereignty over a sea area (archipelago waters) enclosed by straight lines drawn between the outer points of the Islands. However, ships of other states enjoy the right of passage through these waters.

(4) *Exclusive economic zone (EEZ).* Coastal states would enjoy sovereign

rights over a 200 nautical mile (370 km) EEZ from the base line from which territorial sea is measured (Fig.3) with regard to natural resources and other economic activities. The states will also have jurisdiction over scientific research and environmental preservation. Freedom of navigation and overflight and right to lay marine cables will be enjoyed by other states in this zone.

(5) *Continental shelves.* For exploring and exploiting the resources, coastal states would have sovereign right over the continental shelf (see box), which would extend around 200 miles from shore to 358 miles or beyond under specific situations. This would not affect the legal status of waters in this region or the air space above it.

(6) *High seas.* These include such waters which do not come under

internal waters of a state or territorial waters or waters of EEZ or archipelago waters. Freedom of navigation, overflight, scientific research and fishing on high seas would be enjoyed by all states. Consequently management and conservation of living resources in high seas are also the obligation of all states.

(7) *Islands.* As per the rules applicable to land territory, territorial sea, EEZ and continental shelf would be determined for the islands.

(8) *Land locked states.* These states would enjoy right of access to and from the sea and freedom of transit through a transit state (s).

(9) *Marine scientific research.* The coastal states enjoy the right to authorise, regulate and conduct marine scientific research. Any research activity by foreign states in the EEZ and continental shelf of other states

Marine minerals

THE seafloor is a repository of different minerals of economic importance. Most of these minerals now exploited lie in the shallow waters along the continents. This is expected since the continental shelf is an extension of the land and the mineral deposits occurring near the coastal areas, in some cases, extend offshore (e.g., petroleum deposits).

Some of the mineral groups found on the seafloor are (i) aggregates comprising mainly sand and gravel or shells in the offshore areas; (ii) placers which are metallic minerals of detrital origin, found generally in offshore areas (e.g., elements in natural state like gold and platinum and minerals such as zircon, rutile, monazite and garnet); (iii) phosphorites which are sedimentary deposits mainly of phosphate minerals (e.g., apatite) and found in shallow marine environment; (iv) abyssal siliceous deposits (radiolarian oozes) which are pure silica from deep oceans; (v) ferro manganese oxide deposits in the form of nodules and encrustations containing also high nickel, copper and cobalt concentrations and occurring mostly on deep seabed; and (vi) metalliferous sediments which are precipitates of a variety of elements formed as a result of volcanic activity in submarine volcanic areas (e.g., polymetallic sulphides). Of these mineral deposits, manganese nodules and polymetallic sulphides are of considerable economic value, though economic exploitation presently is restricted to placers, sand and gravel.

Manganese nodules. Claimed as the bonanza from the oceans the polymetallic nodules or ferro-manganese or simply manganese nodules are potato-shaped lumps strewn on the ocean floor. Nearly 80%-90% of these nodules lie on seabed beyond the exclusive economic zone. Their quantity is estimated at between 90 billion and 1700 billion metric tonnes with an expected market value exceeding \$3 trillion, an amount more

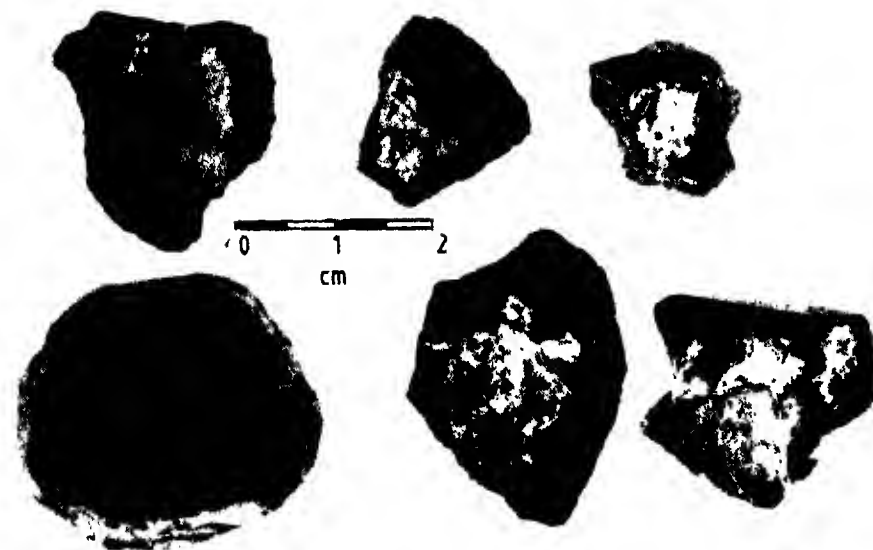


Fig. 4. Polymetallic nodules (Courtesy : Dr. G.S. Roonwal)

than 10 times the combined OPEC oil export revenue during 1980.

Eversince their discovery in 1879 by the British oceanography ship *HMS Challenger*, many collections of these nodules were made from different Ocean areas. These nodules (Fig. 4) which generally occur at depths 3500 m to 6000 m are of irregular shape and size. They form at the rate of 10 million tonnes/year. They comprise varying percentages of Mn-Fe oxides deposited in concentric layers around a nucleus. A typical nodule contains about 28% Mn, 1.4% Ni, 1.2% Cu, 0.25% Co, 0.05% Mo, and nearly 25 trace metals (see *Science Reporter*, August 1981).

The Clarion-Clipperton Fracture Zone between Hawaii and Mexico in the Pacific Ocean appears promising for exploitation of nodules in view of their high density. The technology for the recovery of these nodules is ready. Two principal methods are employed in their mining from deep seabeds: (i) scooping nodules into buckets attached to a conveyor belt and (ii) sucking nodules up a long tube as in a vacuum cleaner. Commercial exploitation of the nodules is likely to start around 1990.

Polymetallic sulphides. Mn-nodules appear to be losing their *prima donna* status with the discovery of polymetallic sulphide ore deposits which are

metalliferous sulphides with metallic elements in a single deposit. First found at the volcanic vents in the Pacific rift near Galapagos ridge in 1977, these deposits occur in many areas as massive bodies of ore pierced by occasional hot vents of 'black-smokers', pouring out high temperature solutions rich in metals. These sulphides contain 10% each of Cu and Fe, 0.1% each of Pb, Mo, Va and Zn and 0.3% each of Ag and Tin. They also contain very low amounts of cadmium, gold and platinum. The total value of metals in the recent find (nearly 25 million tonnes) between Galapagos and Ecuador in the Pacific by the NOAA geologists of US is estimated at \$3,000 million. Sulphides are formed as a result of combined action of volcanism, tectonic fracturing and hydrothermal circulation. Seawater percolating through fracture zones becomes superheated fracture leaches metals from rocks as it passes through them on its way back to seafloor. The metal-rich super-heated (350°C) solution ejected out mixes with cold seawater and precipitates metals in the form of sulphides. Unlike Mn-nodules which are loose deposits lying on seabed, these are massive deposits below the ocean floor.

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would require the consent of the coastal states, which should generally be given, provided it is for peaceful purposes.

(10) *Development and transfer of marine technology.* The states would promote development of technology and transfer of the technology on reasonable terms and conditions.

(11) *Marine pollution.* Coastal states would be responsible for preventing and controlling pollution. They would also cooperate in global environmental protection.

(12) *Deep sea mining outside national jurisdiction.* All activities concerning exploration and exploitation of international seabed area would be under the control of an International Seabed Authority, which will have an operating wing called the Enterprise which would exploit resources (e.g., Mn-nodules) on behalf of all mankind. Under a 'parallel system' the authority would receive proposals from private and governmental enterprises to mine two sites of equal commercial value on the seabed. Of the two sites, one would be reserved for the Enterprise and the other allotted to the applicant (proposer) for mining. The Enterprise could either on its own mine the site or get it mined. The first set of prospectors (applicants) are called the 'pioneer investors' and to qualify for the status of a pioneer investor an incumbent should have spent at least \$30 million on seabed activities and around 10% of this on the seabed claimed for mining. Each pioneer investor would be entitled to mine an area not more than 150,000 sq km.

(13) *Settlement of disputes.* Disputes arising as a result of interpretation or application of the convention may be resolved by peaceful means. For such issues the states can approach the International Tribunal for the Law of the Sea, to be estab-

lished under the convention at Hamburg, Federal Republic of Germany.

India and the Law of the Sea

With the signing of the convention on Law of the Sea, India with its long coastline and 1280 islands is entitled jurisdiction over a 12 nautical mile-wide territorial zone and the same length of contiguous zone and a 200 nautical mile EEZ. Thus with the economic jurisdiction extending to 200 nautical miles an area of more than 2 million sq km, nearly two-thirds of Indian land mass, comes under national jurisdiction providing it with exclusive rights for living and non-living resources. Present estimates suggest around 3 million tonnes of fish production from the EEZ of India.

With the collection of samples of Mn-nodules from the Seychelles basin of the Indian Ocean in January 1981, India joined the exclusive club of developed nations involved in polymetallic nodule activity. The UNCLOS III adopted a convention resolution on 30 April 1982 on preparatory investments in pioneering activity relating to polymetallic nodules, according to which India has been recognised as a pioneer investor along with France, USSR and Japan and 4 other multinational companies headed by USA. This provides India with exclusive rights to operate in 150,000 sq km area in high seas for the recovery and processing of polymetallic nodules. In this connection massive exploration for suitable mine sites has already started. Under the convention, India also gets jurisdiction with regard to marine research in its EEZ.

Conclusion

The sea law convention comes into

force when ratified by over 60 countries. It is hoped that it would establish a legal framework for various uses/activities concerning the sea. It will safeguard the national interest with regard to utilization and distribution of ocean resources and protect the future and well being of all mankind. It may usher in a 'new world order' realising the concept that seas are the 'common heritage of mankind'.

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IMMUNOLOGIC ASPECTS OF SEMEN AND BIRTH CONTROL

Vasectomy has not been found to have any adverse effects in man. In fact, vasectomized men have been found to have longer life span than normal subjects

ATHOTA RAMA RAO
GLEN M. LANG

VASECTOMY, which involves cutting the vas deferens (the spermatic duct) through which the sperm travels, is a very simple birth control method for men (Fig. 1). It is 100% effective in a short time. Consequently, vasectomy is gaining more popularity in the U.S.A. and other countries including India. In the United States one million male sterilizations are performed each year; in the United Kingdom it has been estimated that 1 in 10 men have had a vasectomy by the time their wives were 35; in India more than 20 million vasectomies had been performed by 1979 (Kleinman, R.L., 1980).

Semen and its antigens

Mammalian spermatozoa (Fig. 2) possess sperm specific antigens which are normally hidden from the immune system by a blood-testis barrier. Animals injected with homologous sperms in Freund's complete adjuvant produce antibodies that agglutinate and develop a moderate degree of infertility. In humans antisperm antibodies cannot be distinguished from antiserinal plasma antibodies. This suggests that the major antigens of ejaculated human sperm might be derived from seminal plasma, which contains numerous potentially immunogenic proteins and enzymes. So far, at least 16 antigens have been identified in semen, seven of which are associated with

sperm (H.Hugh Fudenberg *et al.*, 1980).

Many techniques have been described for the detection of antisperm antibodies in serum and other body secretions, but only two are commonly used. They are the sperm agglutination test and the sperm immobilization test. Other methods, especially immunofluorescence, enzyme immunoassays (EIA) and radioimmunoassays (RIA) show promise and would seem to justify further developments as reliable clinically relevant assays for antibodies to human spermatozoa.

Presence of antibodies to semen in the uterus

In some studies in women, approximately 75% of patients with primary infertility had serum sperm agglutinins. However, 11%–15% of pregnant women also had the same titers of antisperm antibody. Antisperm antibody present in cervical secretions are thought to prevent the normal penetration of sperm into the uterus (D.P.Stiles *et al.* 1982). The titer or antibodies in female patients may diminish if she refrains from sexual intercourse or if a condom is used by her partner.

In recent years, a number of reports have appeared implicating constituents of human seminal fluid as responsible for severe allergic conditions such as urticaria, angioedema

and respiratory obstruction in women after sexual intercourse (J.b.Kooistra *et al.* 1978).

The discovery of immunosuppressive factors in seminal plasma raises important questions about the immunogenicity of semen components. It is interesting to speculate that naturally occurring immunosuppressants in seminal plasma may play a role in protecting women from becoming immune to sperm (H.Hugh Fudenberg *et al.* 1980).

Prospects for an antifertility vaccine

The antifertility properties in semen

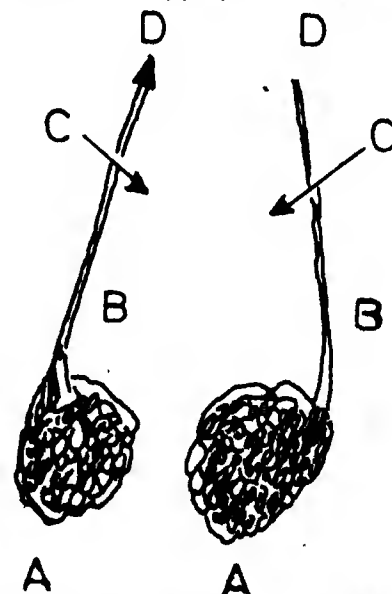


Fig. 1. Location of incision in vasectomy. A, testicle; B, vas deferens; C, incision point; and D, route to seminal vesicles

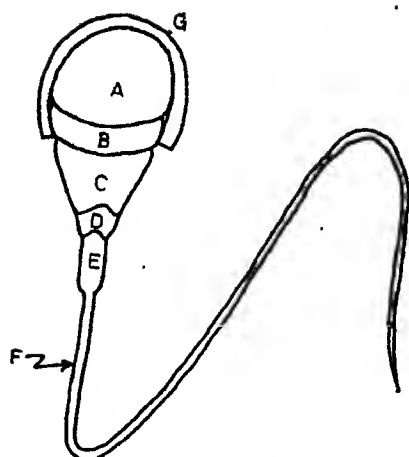


Fig. 2. Anatomy of spermatozoa. A, sperm head; B, equatorial section; C, post-nuclear cap; D, neck; E, midpiece; F, tail; and G, acrosome

are associated with sperm antigens and not with those of the seminal plasma (G.P.Talwar 1980). Antibodies to sperm antigens can agglutinate, immobilize or inactivate the spermatozoa, with the result that fertilization with ova is inhibited. The important antigens considered in this respect are Lactic Dehydrogenase-X (LDH-X), Hyaluronidase and Acrosin (Fig. 2). LDH-X is located intracellularly and on the sperm surface. Mice that were immunized with purified LDH-X suffered significant reduction in fertility (R.P.Ericksom *et al.* 1975) but not complete sterility. The antibodies to hyaluronidase inhibit the hydrolytic activity of the enzyme and its apparently essential biological function in reproduction namely sperm penetration of the cumulus (a mass surrounding ova) (C.B.Metz *et al.* 1972). Sperm penetration of the zona pellucida is achieved by the action of acrosomal proteinases, notably acrosin. Female sheep that have been actively immunized with ram acrosin may have impaired fertility (D.B. Morton, 1977). However, an

effect approaching sterility has not been reported. Examination of sera from men whose infertility was associated with the presence of antisperm antibodies has defined, distinct antigenic regions of human spermatozoa. In Fig. 3 are depicted the most common immunofluorescent patterns obtained when autoiologous antisperm antibodies are incubated with human sperm and then developed with fluorescence labelled anti-human immunoglobulin.

Immunologic consequences of vasectomy

A breach of the blood-testis barrier by vasectomy can result in the generation of sperm agglutinating autoantibodies. Several studies have shown that these antibodies are found in the serum of 70% of vasectomized men (T. Samuel *et al.*, 1980; and Rumke *et al.*, 1959). Little is known about cellular immunity to sperm following vasectomy. The immediate concern has been the possible influence of these antibodies on subsequent fertility after vasovasostomy (recanalization). The results from several studies on the presence of sperm agglutinins in fertile and infertile men are presented in Table 1 (L. Mettier *et al.*, 1974). It can be seen that the incidence of antisperm antibodies is higher in infertile men than in fertile men but its relationship to the infertile condition is not clear,

On the whole, there are no established adverse systemic immune effects of vasectomy in humans. In 1968 (Stites *et al.*, 1982) a few patients with vasectomy were reported to have thrombophlebitis, glomerulonephritis, or multiple sclerosis, but these symptoms have not been correlated with vasectomy when larger groups have been followed. In addition, sex hormone levels are not influenced by

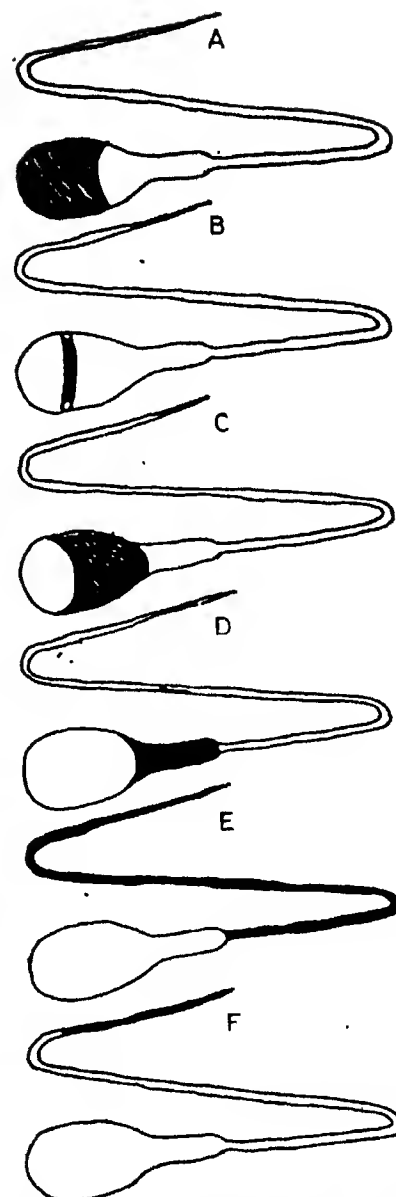


Fig. 3. Immunofluorescent staining patterns of spermatozoa by sera of infertile men, indicated by the shaded areas. A, anterior region of head; B, equatorial area; C, post-nuclear region; D, midpiece; E, tail; and F, tip of tail. [Redrawn from Halez, E.S.E., (1976), Editor, *Human Semen and Fertility Regulation in Men*, The Mosby Company, St. Louis, USA]

vasectomy. There is fragmentary evidence for circulating immune complexes of sperm antigens and antibody following vasectomy in men.

Clarkson *et al.* (1980), have reported that rhesus monkeys vasectomized for 9-14 years and fed monkey chow devoid of cholesterol and low in fat, rather than an atherogenic diet, had

Table 1. Sperm agglutinating antibodies

Infertile men		Fertile men	
Number of subjects	% with antibody	Number of subjects	% with antibody
400	6.8	500	none
1913	3.2	416	2.6
2015	3.3	416	none

more extensive and severe atherosclerosis than did control animals of the same age. They suggest that the antisperm antibodies that form after vasectomy may result in circulating immune complexes that exacerbate atherosclerosis. However, the animal studies have not been supported by retrospective studies in man. Frank Massey (1983) reported that ten years after surgery, men who have had vasectomies were at least as healthy as men who did not have. One of the encouraging observations in this report was that in a study conducted in Boston University Drug Epidemiology Unit in collaboration with hospitals in the New England-New York area, the deaths from heart disease and cancer were significantly higher in men without vasectomies. The reasons for the lower death rates among vasectomized men are not known.

Conclusion

In conclusion, the use of vasectomy as a birth control method has not been shown to have any adverse effects in man. Moreover, some investigators have reported that for unknown reasons, the vasectomized men have a longer life span than normal subjects. Research on antibodies to sperm antigens, ova and sex hormones may lead to the development of a "vaccine" for use in birth control,

and make available another option for couples who are interested in long-term birth control free from surgical procedures or drugs and without the necessity of inserting or wearing various contraceptive devices.

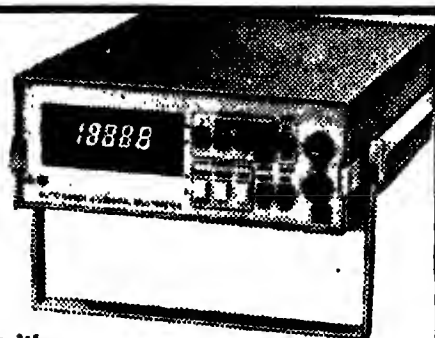
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GALLIUM :EKA-ALUMINIUM OF MENDELEEV

R. KRISHNA IYER

In the history of chemistry, the discovery of gallium is significant as it led to the widespread recognition of Mendeleev's periodic system of elements

GALLIUM was discovered in 1875 by the French Chemist, Lecoq de Boisbaudran. The observation of a gap between aluminium and indium during the study of the spectral lines of Gr III elements of the periodic system prompted Boisbaudran to carry out extensive research. After examining hundreds of mineral samples, he located the missing spectral lines in a sample of zinc blend. Dissolution of zinc blend in aqua regia and treatment with zinc gave a deposit which emitted two new violet lines in an oxy-hydrogen flame. The name gallium was assigned to the new element in honour of France. Gallia is Latin for France. The discovery of gallium is significant in the history of chemistry since it brought widespread recognition of Mendeleev's periodic system of the elements. The correspondence between the properties of gallium and the predicted properties of Eka-Aluminium by Mendeleev are remarkable. For example, the metal prepared by Boisbaudran had a specific gravity of 4.7. Mendeleev had pointed out that gallium should have a specific gravity of 5.9. Subsequent isolation of the pure metal with specific gravity of 5.94 confirmed this view.

Properties

Gallium is a silvery white metal with several exceptional properties. It is

the only metal other than mercury and caesium having a very low melting point (29.78°C), but in contrast to mercury, it wets glass readily. Of all the elements, gallium has the longest liquid interval (boiling point $>2200^{\circ}\text{C}$). It is readily supercooled down to a temperature as low as -120°C . The pure liquid may be held in an ice bath for days without crystallising. Liquid gallium expands during solidification (3.2%)— a property shared by only three other elements: antimony, bismuth and germanium. The metal crystallises in the orthorhombic system and the crystal lattice contains Ga_2 molecules. Such coexistence of molecular and atomic structures is rarely observed. Ga_2 molecules exist in the liquid state also. Since gallium melts and solidifies at temperatures prevailing during storage and transportation, polyethylene containers are preferred.

Crystals of gallium are anisotropic. The electrical resistances along the three crystallographic axes are in the ratio 1:3.2:7. The ratio of maximum to minimum electrical resistance in different directions is 7. This is the highest for any metal. Gallium diffuses very fast into the crystal lattice of certain metals, particularly aluminium and makes them brittle. Because of this property, there are restrictions in airshipment of gallium. Gallium alloys readily with many metals.

In its chemical properties gallium resembles zinc and is somewhat less reactive than aluminium. Like aluminium it is protected from air oxidation by a superficial film of oxide. Pure gallium is slowly attacked by dilute mineral acids and alkalis at room temperature. It dissolves rapidly in hot concentrated perchloric acid and aqua regia. The rate of reaction of gallium with acids and alkalis decreases considerably as the purity of gallium rises above 99.9%.

Gallium oxide is amphoteric, but is more acidic than alumina. Hence gallate solutions are less susceptible to hydrolysis than aluminates. This difference in property is made use of in commercial separation of gallium from aluminium. Gallium reacts with halogens, except iodine, even in the cold. Gallium trichloride is soluble in many organic liquids which forms the basis for its use as a catalyst in organic synthesis. In hydrochloric acid medium GaCl_3 forms the complex acid HGaCl_4 , which can be completely extracted into isopropyl ether. Since aluminium is not extracted, Ga can be quantitatively separated from Al by this method.

Occurrence

Gallium was classified as a rare element for a long time after its discovery. Later it was found to be a fairly widely distributed metal, its abundance being approximately equal to that of lead and 30 times that of mercury. It occurs in nature in association with Zn, Ge or Al (its closest neighbours in the periodic system (Fig. 1). The ionic radius of Ga^{3+} (0.62 \AA) is close to that of Al^{3+} (0.57 \AA). Substitution of Ga for Al ions is possible in the crystal lattices of aluminium minerals. However, there are no minerals sufficiently rich in gallium to make its direct extraction economically feasible. The only gallium mineral, gallite (Cu_3GaS_2), which is rare, is found in Africa. Bauxite, the principal ore of aluminium, contains 0.001%–0.008% Ga.

	III A	IV A
	5 B	6 C
	13 Al	14 Si
II B		
30 Zn	31 Ga	32 Ge
48 Cd	49 In	50 Sn

Fig. 1. Location of Ga in the periodic table

Production of gallium

Gallium is mainly recovered as a byproduct of the aluminium industry. In the Bayer process for preparation of pure alumina, bauxite is dissolved in caustic soda, and aluminium oxide trihydrate is precipitated by seeding and cooling. The mother liquor is recycled for dissolution of more bauxite. After several cycles, gallium builds up in the liquor to an equilibrium concentration of 0.1 g/litre. Gallium can be recovered from the liquor by either carbonation or amalgam method.

Since gallia is more acidic than alumina, controlled carbonation of Bayer liquor gives a precipitate rich in $\text{Al}(\text{OH})_3$. Gallium rich concentrate is obtained at the end which is dissolved in NaOH and electrolysed to get metallic gallium.

The amalgamation method is based on selective extraction of metals by mercury followed by their selective dissolution from the amalgams formed. It makes use of the difference in solubilities of different metals in mercury and their potentials for electrodeposition on mercury. A familiar example is the industrial production of caustic soda and chlorine employing mercury cells. The reversible deposition potential of sodium from 1M solution of sodium chloride is about -2.7 volts, but as a result of formation of

compounds (NaHg_2 and Na_3Hg) which are soluble in mercury, appreciable discharge of sodium ions occurs even at -1.2 volts. Due to the high over voltage for deposition of hydrogen on mercury (-0.8 V) simultaneous discharge of Na and hydrogen can occur.

The solubilities of gallium and aluminium in mercury at 25°C are 1.3% and 0.003% (W/W) respectively while the standard potentials for deposition from alkaline solutions are -1.22 and -2.35 volts respectively. Electrodeposition of Al from aqueous solution is not possible due to the large negative value of the electrode potential. Though the gallium concentration in Bayer liquor is very low, electrodeposition is made feasible by the solubility of gallium in mercury. However, the current efficiency is low (5%) due to the side reactions, viz., deposition of sodium and evolution of hydrogen

Recovery of gallium from Bayer liquor is carried out by using a mercury cathode and nickel or stainless steel anode. The optimum conditions are: cathode current density, 1A/dm². Temp., 50°-60°C. During the process both the electrolyte and the mercury are stirred. When the gallium content in the amalgam attains a value of 0.5%, gallium is leached out from the amalgam with sodium hydroxide in presence of graphite or iron as a catalyst. The sodium gallate solution thus obtained is electrolysed with stainless steel electrodes to get metallic gallium. The amalgam method is non-destructive and the liquor after recovery of gallium is recycled for processing fresh bauxite.

Indigenous production of gallium

India has a large aluminium industry, the chief producers being Hindustan Aluminium Co., (U.P.), Madras Aluminium Co., (Tamil Nadu), Indian Aluminium Co., (West Bengal) and Bharat Aluminium Co., (M.P.). The total installed capacity is about 0.3 million tonnes which requires processing of about 2 million tonnes of bauxite. India is very rich in bauxite Bihar, Goa, Gujarat, Karnat-

aka, Madhya Pradesh, Maharashtra and Tamil Nadu are the states from where the ore is being exploited presently. There are promising reserves in Andra Pradesh, Kerala, Uttar Pradesh and Jammu Kashmir. The reserves of bauxite of all grades have been estimated at 1250 million tonnes.

The potential availability of gallium as a byproduct of the aluminium industry is estimated at 3000 kg/year. Process for the recovery of gallium from Bayer liquor by deposition on mercury cathode was developed at the Bhabha Atomic Research Centre (BARC), Bombay, and the Central Electrochemical Research Institute, Karaikudi. Based on the process developed at BARC, HINDALCO is presently producing kilogram quantities of gallium. Work on the setting up of a pilot plant at HINDALCO is in progress.

High purity gallium

The major use of gallium is in the semiconductor industry which requires gallium of 99.999% purity or higher. Partial purification of the metal is achieved by washing with a mixture of nitric acid and hydrochloric acid (1:4 ratio + equal volume of water) and filtering through sintered glass plates. The purity of the metal rises to 99.9%-99.99%. The methods described in literature for preparation of high purity gallium include electrolytic refining, heating the metal under vacuum, zone refining of gallium metal as well as gallium trichloride, fractional distillation of gallium trichloride, etc. The process developed at the Bhabha Atomic Research Centre, Bombay, involves the following steps: (1) chlorination of commercial gallium at 200°C-300°C, (2) Fractional distillation of gallium trichloride, (3) Conversion of gallium trichloride to sodium gallate by treatment with sodium hydroxide, (4) Electrolyses of sodium gallate by using gallium cathode, and platinum anode and (5) Anodic polarisation of gallium in 4 N HCl. By using this process, gallium of 99.999% purity is being prepared at the Special Materials Plant, Nuclear Fuel Complex, Hyderabad, of the Deptt. of Atomic Energy.

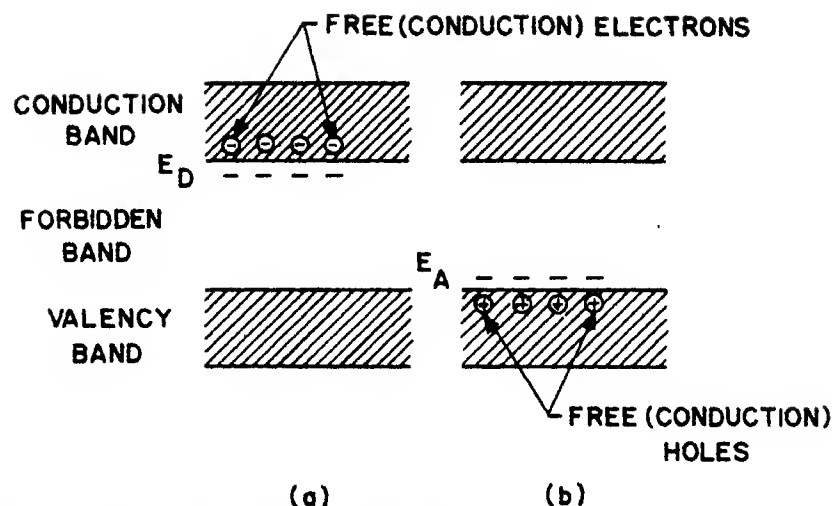


Fig. 2. Energy band diagrams of extrinsic semiconductors containing (a) n-type and (b) p-type impurities E_D = Energy level of donor. E_A Energy level of acceptor

Uses

High purity gallium (99.999% or higher — total impurity content 10 parts per million or less) is used in the semiconductor industry. It is a dopant for making p-type semiconductors. The major requirement is in the form of compound semiconductors (III/V compounds), the most important being gallium arsenide and gallium phosphide. Many mixed compounds like $GaAs_{1-x}P_x$, $Ga_{1-x}Al_xAs$ and $GaIn_{1-x}P_yAs_{1-y}$ are also used. All these are employed for making light emitting diodes (LEDs) and semiconductor lasers. A familiar use of LEDs is in digital displays. The mechanism by which LEDs convert electricity into optical radiation is explained below.

All technologically important LEDs are p-n junction diodes. The band gap in them is large compared to the thermal energy at room temperature (band gap of GaAs = 1.4 eV); n- or p-type semiconductors is obtained by incorporating into the host crystal impurity elements with more or fewer valency electrons than are required for bonding of the impurity atom into the crystal structure (Fig.2).

The impurity levels that are useful for LEDs and lasers are usually shallow. The forward biasing of the junction diode causes current to flow and results in the injection of carriers across the p-n junction (Fig.3). Emission of electromagnetic radiation

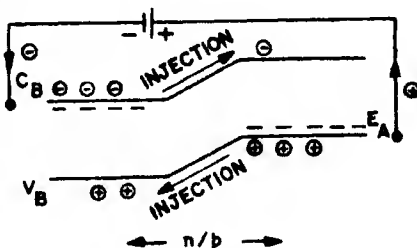


Fig. 3. p-n junction after application of forward bias

may result from electronic transition from a higher to a lower energy state.

$$E = \frac{hc}{\lambda}$$

E = energy of transition, h = Planck's constant, c = velocity of light and λ = wavelength of photons emitted. If recombination of the injected carriers (hole and electron) occurs by a radiative transition, light of approx. the band gap energy is generated. If a useful fraction of this light can escape into the surroundings, the device is an LED.

In recent years, there has been considerable progress in the development of telecommunication systems with optical fibres. These consist of three components: light source, detector and transmission medium. The light sources include LEDs and injection laser diodes while glass fibres form the transmission medium. Silicon semiconducting devices are used as detectors. The potential for lightwave communications is enormous due to the very high information

carrying capacity of visible and infrared radiations as compared to radiowaves. For example, modulated infrared radiation from (Ga,Al) As laser can transmit speech over 20,000 telephone channels. Optional communication systems which use InGaAsP laser diodes have been installed in Japan. The total world wide fibre optics systems production is estimated to reach \$1.5 billion by 1990.

Microwave oscillators, high temperature rectifiers, solar cells and fast switching integrated circuits employ GaAs or GaP. MgGa spinel doped with Mn is used as a green emitting phosphor for luminescence tubes in copying machines. Ga is used as a thermometric standard. Its melting point of 29.7714°C is used as a thermometric fixed point between 0°C and 100°C. Gadolinium gallium garnet is a magnetic material used in the manufacture of computer memories. Gallium finds application as a thermometric liquid in quartz thermometers for measuring temperatures between 600°C and 1500°C. Low melting alloys of Ga are used in cold soldering of metallic and ceramic articles. Some alloys of gallium are used in dentistry.

Conclusion

The world consumption of gallium in the late 1950s was below 100 kg/year which has increased to more than 15 tonnes/year in recent years. Presently, the indigenous requirement of high purity gallium is only in kilogram quantities. The technology for the production of LEDs and high intensity solar cells is being developed by the Central Electronics Ltd., Sahibabad, U.P. Hence the demand for gallium is expected to go up considerably in the near future.

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THE ENIGMATIC THYROID HORMONES

Thyroid is the most investigated and the least understood of all the endocrine glands

V.K. PATHAK

A.K. PATI

THYROID is present in all vertebrates and has the credit of being the most investigated (and less understood!) of all the endocrine glands. In man and other mammals, it is bilobed and is found attached to the anterior part of the trachea. Histologically, thyroid gland is composed of follicles consisting of epithelial cells (columnar or cuboidal) that surround a central lumen filled with a proteinaceous substance known as colloid (also called thyroglobulin). Thyroglobulin is glycoprotein having iodinated amino acid molecule(s) (referred to as tyrosyl or tyrosine residues) with carbohydrate moieties

Transport of thyroid hormones

In blood, albumins, prealbumins and globulins are the carrier proteins for thyroid hormones. While globulins (TBG) are the principal carrier of a large percentage of thyroid hormones (both T_4 and T_3), very small amount of the hormones is transported in blood bound to albumins and prealbumins. However, binding capacity of TBG is greater for T_4 than T_3 . At peripheral level thyroid hormones are freed from protein carriers and after passing through capillary walls, impinge on cells of the tissues.

Thyroid functions

Thyroid hormone(s) has multiple physiological effects. However, its metamorphosing effects in amphibia and stimulatory action on oxygen consumption and growth of homeotherms and poikilotherms are best known examples. Besides these, many other metabolic processes such as intermediary metabolism, differentiation of growing animals, brain maturation, reproduction, etc., are also influenced by thyroid.

Clinical abnormalities

Improper functioning of thyroid leads to disturbances in animal physiology. Classically, hyper and hypo-functioning of thyroid are referred to as hyper and hypothyroidism, respectively. The former results from excessive and the latter from suboptimal production of thyroid hormone(s).

(A) *Hyperthyroidism* Nervousness, anxiety, tachycardia (excessive rapid heart action), enhanced basal metabolic rate (BMR), excessive sweating, increased appetite with weight loss and fine tremor of the outstretched hand with prominence of eyes are main symptoms observed in hyperthyroidism. These abnormalities are also sometimes termed as thyrotoxicosis. Thyrotoxicosis in early life leads to delayed sexual maturation whereas after puberty it influences reproductive function especially in women. Nymphomania (excessive sexual desire in females), disturbed menstrual function, impaired fertility and threatened abortion may result from thyrotoxicosis in females. However, increased libido may occur in both sexes. Severe thyrotoxicosis, if not treated, leads to cardiac irregularities and death.

(B) *Hypothyroidism*. In contrast, hypothyroidism is characterised by apathy, lethargy, somnolence (a state of dissociated consciousness in which sleeping and walking states are combined), decreased BMR, cold intolerance, bradycardia (slow heart rate), weight gain and constipation. Hypothyroidism before puberty results in the disease cretinism. Cretins fail to attain normal physical and or mental development. In adults hypothyroidism causes myxoedema. Low BMR, obesity and coarsening of features are common symptoms of this disease. Female myxoedematous complain of hypermenorrhea, male patients of impotence, and both sexes of decreased libido. Major cause of hypothyroidism is prolonged iodine

Hormonogenesis

In the presence of enzyme systems e.g., peroxidase and iodinase, dietary iodine circulating as inorganic iodide (I^-), is oxidized to elemental iodine (I_2). Tyrosine residue is first iodinated to monoiodotyrosine (MIT) and then to diiodotyrosine (DIT). Molecules of MIT and DIT are coupled (enzymatically) to form triiodothyronine (T_3 : MIT+DIT) or tetraiodothyronine (also called thyroxine (T_4 , DIT+DIT)). The synthesized hormone(s) (T_3 or T_4), which is stored as colloid is released after proteolytic degradation of the thyroglobulin by pinocytosis and finally diffuses into plasma. MIT and DIT are generally not released into circulation. Unutilized MIT and DIT are deiodinated, and resulting iodide is retained and forms part of the thyroid iodide pool. Obviously, T_3 and T_4 are the thyroid hormones present in the blood.

Table 1. Circulating free thyroxine (FT₄) and triiodothyronine (FT₃) concentrations in different thyroidal status of man

Thyroid Status	FT ₄ (pg/ml)	FT ₃ (pg/ml)
Euthyroid	7.5—17.0	3.5—6.5
Hypothyroid	1—5	0—3
Hyperthyroid	26—60	18—40

Based on reference Ellis & Ekins, (1973)

deficiency which ultimately renders thyroid hyperplastic. Decreased level of thyroid hormone(s) in blood results into increased pituitary thyrotropin (TSH). In response to increased TSH stimulation thyroid gland becomes progressively larger and consequently goitre develops. In chronic hypothyroidism impaired level of consciousness, cardiac arrhythmia and hypothermia may prove fatal.

Ecology and thyroid function

In certain areas (Himalayas, for example) where dietary iodine is deficient, there is large incidence of endemic goitre. But goitre may be absent in some individuals of these areas. It is due to preferential secretion of T₃ by thyroid. It is postulated that (a) the saving of one iodine per molecule, (b) the greater metabolic activity of T₃, and (c) its more rapid turnover results in a more economical expenditure of available iodine. Such an increase in the efficiency of iodine utilization leads to apparent adaptation of three individuals to chronic dietary iodine deficiency without the usual thyroid hypertrophy (endemic goitre). Adaptive instances of thyroid have been reported from other geographical regions also.

Assessment of thyroid function

Generally, assessment of thyroid activity in health and disease involves: (a) test thyroid hormone effects and/or, (b) determination of thyroid hormone levels.

A. Magnus-Levy, a German physician in 1895, was first to introduce the use of basal metabolic rate as a convenient and effective method for

determining level of thyroid function. Since several endocrine and non-endocrine factors including age, sex and environmental temperature, etc., interfere with metabolism, this age-old-test lost preference (but not validity) in favour of more sophisticated methods, viz., plasma protein bound iodine (PBI), isotope labelling and radioimmunoassay (RIA), etc.

(A) *PBI and radioiodine (¹³¹I and ¹²⁵I) methods.* Taking into consideration that thyroid hormone(s) in blood, like many other hormones, is transported bound to plasma proteins, a method was evolved to determine the plasma PBI. Generally, high and low PBI reflects hypo and hyper functions of thyroid, respectively. But since PBI may be high in conditions of low thyroid activity also, this method is no longer satisfactory for determination of thyroid activity.

Iodine trapping is a unique property of thyroid gland. This specificity of thyroid for iodine led to the use of radioiodine (¹³¹I and ¹²⁵I) for direct estimation of thyroid function. Radioiodine uptake reflects the activity of the iodine pump and organification steps in hormone biosynthetic pathway. Generally, hypothyroidic patients have low radioiodine uptake while hyperthyroidics higher than the normal (Euthyroidic) subjects. However, since the rate of radioiodine trapping gives a gross account of iodine utilization and not of the changes in thyroid hormone levels, this method too is not reliable for test of thyroid activity.

(B) *Radioimmunoassay (RIA) methods.* In 1960s taking hint from R.S. Yalow and S. Berson's suggestion (at Mount Sinai School of Medicine, New York) for measurement of plasma insulin by radioimmunoassay (Yalow won Nobel Prize in 1977 for discovering this method), thyroid physiologists employed a similar method for determination of thyroid hormones in animals. Success of this revolutionary and specific method was largely due to the earlier demonstration of immunological property of thyroxine and use of this property for measurement of concentrations of thyroxine by Prof. R.P. Ekins at Mid-

Table 2. Circulating total thyroxine (± T₄) and triiodothyronine (± T₃) concentrations in euthyroidic, hypothyroidic and hyperthyroidic human subjects

Thyroid Status	T ₄ (ng/ml)	T ₃ (ng/ml)
Euthyroid	40—120	0.75—1.75
Hypothyroid	25—80	0.3—0.8
Hyperthyroid	110—400	2—10

Based on references Evered, (1975); Larsen, (1978)

drex Hospital Medical School, London. RIA procedure has been widely adopted in recent years for the study of concentrations, sources and metabolism of thyroid hormone(s) and many of its metabolites, and is the most evolved method available for such studies on thyroid.

Nevertheless, the drawback with conventional RIA is that it fails to detect free and bound hormone(s). Since, it is the free amount of any hormone which is physiologically active at peripheral level, and not that which remains bound to its carrier protein(s) the existing RIA technique has been suitably modified. This modification of RIA enables measurement of free T₄ and T₃ concentrations for sensitive and accurate estimation of thyroid activity. Table 1 summarises concentrations of plasma free T₄ and T₃ in different thyroid conditions.

In brief, results of various assays of thyroid hormone(s) have indicated that low serum T₄ and T₃ concentrations are generally found in hypothyroidism while low serum T₄ and normal T₃ concentrations are associated with mild thyroid failure. However, normal T₄ and elevated T₃ concentrations are observed in some instances of: (a) hyperthyroid state, (b) thyroid autonomy with euthyroidism, and (c) compensatory euthyroidism. Elevated T₄ and T₃ concentrations are however found in hyperthyroidism. Table 2 summarises the concentrations of plasma T₄ and T₃ in hyper, hypo and euthyroidic subjects.

Recent developments

Knowledge of thyroid physiology

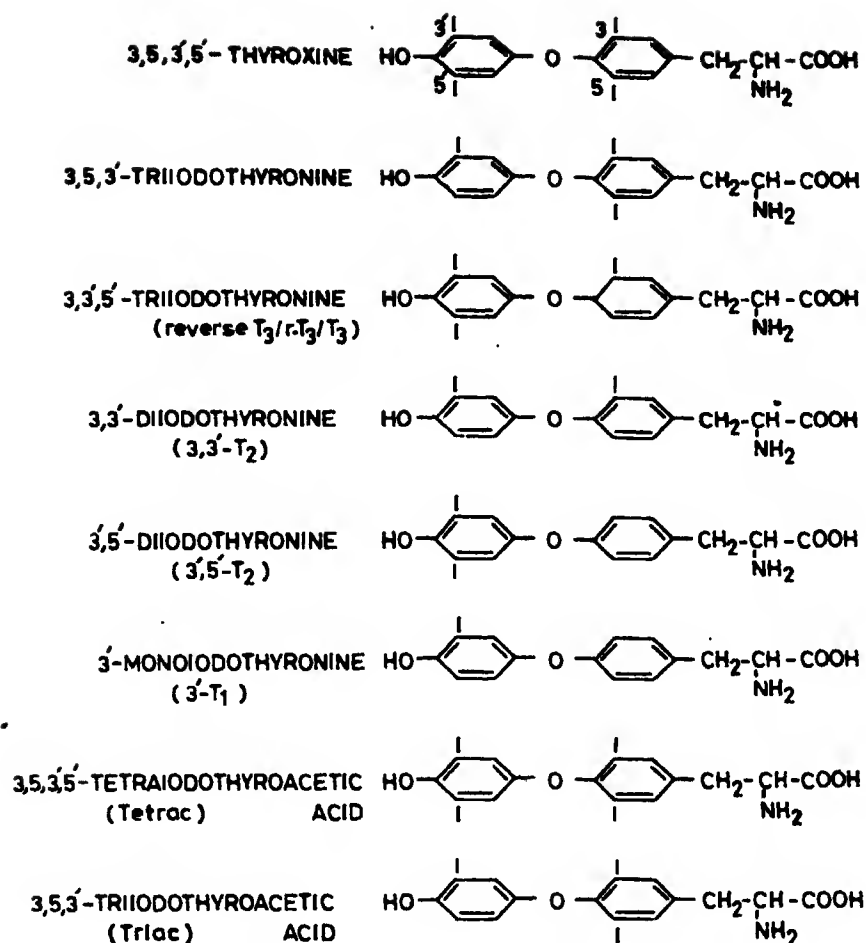


Fig. 1. Structural formulae for different iodothyronines and analogues detectable in human circulation

has progressed rapidly in the past 30 years.

T₄ and T₃. In retrospect, until 1949 thyroxine was believed to be the sole hormone of thyroid gland and the direct Initiator of thyroid hormone action at peripheral level. However, the situation changed and it was demonstrated in 1950 by J. Gross and R. Pitt-Rivers at Department of Anatomy, State University of New York College of Medicine, New York City, that T₃ is an active biological principle of thyroid, and that T₄ is a large precursor pool for maintenance of constant effective thyroid hormone concentration in the animals. This was followed by a revolutionary landmark in 1970 provided by L.E. Braverman and colleagues at St. Elizabeth Hospi-

tal, Brighton, Massachusetts. They demonstrated peripheral conversion of T₄ into T₃ in athyreotic human subjects receiving highly purified thyrox-

ine. This discovery raised two questions: (1) to what extent T₄ is converted into T₃, and (2) whether the conversion of T₄ into T₃ is a prerequisite for metabolic action of thyroid.

γ-T₃, T₂, T₁ and T₀ and fatty acid analogues of T₄. The search for an answer to the first enquiry led to the discovery of some more peripheral converts (besides T₃) of thyroxine. In this class are included tetrac and triac (fatty acid analogues of T₄) and iodothyronines, viz., reverse-T₃ (γ-T₃), T₂, T₁ and T₀. The latter (γ-T₃, etc.) are produced by progressive deiodination of T₄. Fig. 1 summarises the structural formulae for iodothyronines and analogues detectable in human circulation.

Presence of γ-T₃ in blood was first doubted in 1956 by J. Roche and coworkers at Biochemie générale et Comparée, Collège de France, Paris. But Prof. I.J. Chopra and colleagues at the UCLA School of Medicine, Los Angeles, have recently quantified both γ-T₃ and T₂ in human circulation using specific RIA techniques. Biochemically, the only difference between T₃ and γ-T₃ is that in the former phenolic ring and in the latter tyrosyl ring T₄ is deiodinated at position 5. This results in an arrangement where γ-T₃ has two iodine atoms in the outer ring and one in the inner ring. In contrast, in T₃ the arrangement is just opposite to γ-T₃ see Fig. 1). Both T₃ and γ-T₃ may further be deiodinated to 3,5-, 3,3'- and 3,5' diiodothyro-

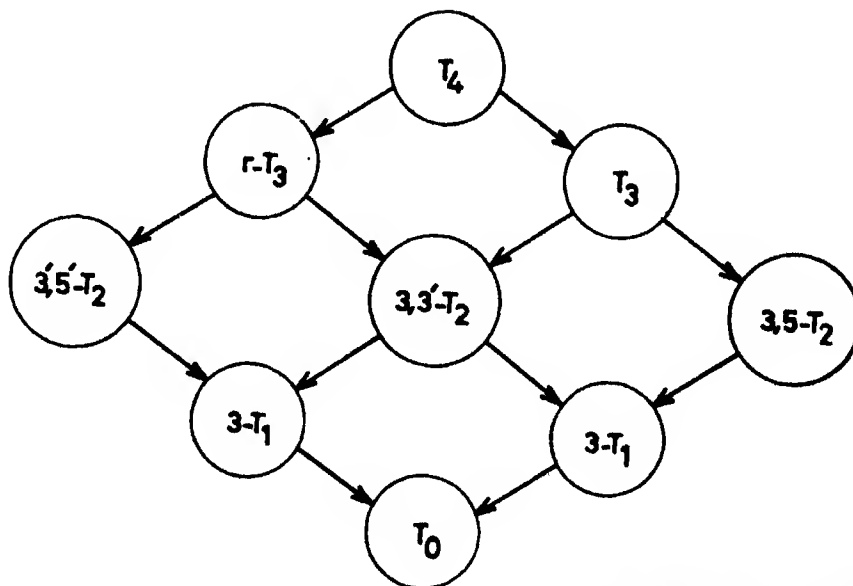


Fig. 2. Metabolism of thyroxine (T₄) by 5- (↙) and 3'- (↘) deiodination (↘)

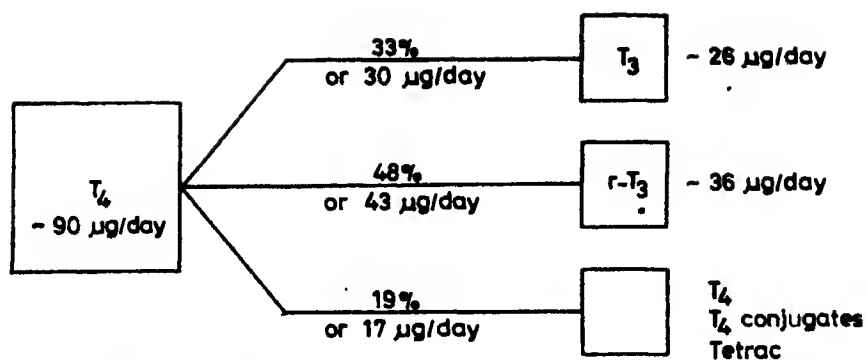


Fig. 3. Quantitation of metabolic pathway of thyroxine in human subjects (from Chopra *et al.*, 1978)

nine (T_2) than to 3 and 3'-iodo-thyronine (T_1) and finally to thyronine (T_0) (Fig. 2). Less than 5% of T_4 is transformed into tetrac and triac. However, in starvation this pathway may increase slightly. About 33% of the T_4 from thyroid is transformed into T_3 while 48% is used for $r-T_3$ production. Some percentage out of the rest 14% (approximately) of T_4 is transformed into T_2 , T_1 , and T_0 and the remaining percentage is metabolized (largely in liver and kidney) as such (Fig. 3).

Relative potencies of thyroid hormones

The question whether conversion of T_4 into T_3 is a prerequisite for metabolic action of thyroid hormone has not been fully resolved yet. However, among the various iodothyronines present in plasma only T_3 , T_4 , triac and tetrac have calorogenic activity. Reserve — T_3 , 3-3' — T_2 , 3-5' — T_2 , 3' — T_1 and T_0 are inactive in calorigenesis, although reportedly they may possess some metabolism stimulating properties. The relative potencies with respect to calorigenesis of T_3 , T_4 , triac and tetrac are approximately 300:100:21:11, respectively. From these data, it is evident that T_3 is more active than T_4 . In instances where there is caloric deprivation, peripheral metabolism is shunted from activating to inactivating pathway. As a result, more $r-T_3$ than T_3 is produced from T_4 .

Mechanism of action

A unified model for mechanism of

action of thyroid hormone(s) which could effectively explain its role in metamorphosis, growth and in oxygen uptake has not emerged so far. Possibly two mechanisms are involved in thyroid hormone(s) action: one which concerns growth and metamorphosis, and the other, oxygen consumption.

Receptors to thyroid hormones have been detected in cytosol nucleus and mitochondria. Binding of free hormone(s) to receptor(s) is a prerequisite for expression of physiological effect of the hormone. Credit goes to Dr. J.R. Tata of the National Institute for Medical Research, London, for establishing this involvement of DNA dependent RNA synthesis in thyroid hormone action. Recent studies indicate that thyroid hormones bind directly to the non-histone acidic proteins associated with chromatin in the nucleus. The association of hormone molecule with the receptor (nuclear binding proteins) follows structural change in the chromatin that influences transcription of specific genes. Subsequent to this, mRNA and protein synthesis takes place. This stimulatory role of thyroid hormones on protein synthesis may account for its role in growth and in amphibian metamorphosis.

Earlier concept that thyroid hormone(s) uncouples oxidative phosphorylation at the respiratory chain has been discarded because this mechanism of action was later found to be pharmacological in nature. According to recent findings, in thermogenesis (homeotherms) and in oxygen consumption (poikilotherms) thyroid hormone(s) may have two

types of responses. In one instance, the action is immediate and occurs within hours or even minutes, and in the other it may express after a long period. The latter may or may not follow the former, or, the latter may express itself even if the former is absent. In the first instance, the action of the hormone is directly on the mitochondrial respiration and in the other the effect occurs via time consuming process of protein synthesis.

Feedback control

Under environmental stimuli, viz., temperature, light and food, etc., TRH (thyrotrophin releasing factor) is secreted from the hypothalamus. This influences anterior hypophysis to produce enhanced amounts of TSH (thyroid stimulating hormone or thyrotrophin). TSH stimulates homonogenesis and release of thyroid hormones (T_3 and T_4) from thyroid. Excess amount of circulating thyroid hormone(s) exerts inhibitory effect both at hypothalamus and hypophysis. As a result, there is decrease in TRH and TSH. This is known as negative feedback. Decreased level(s) of T_3 and T_4 in plasma stimulates TRH production which in turn enhances TSH concentration. This is called positive feedback.

Antithyroid drugs

Pharmacological agents like propylthiouracil, thiourea, iopanoic acid, etc. have been shown to inhibit peripheral conversion of T_4 into T_3 by about 60%-70%. These agents are called goitrogens and are helpful in treating hyperthyroidism besides being useful as thyroid blockers in research.

Thyroid physiology

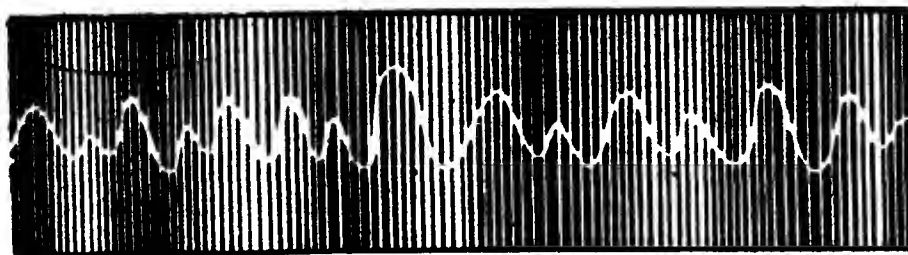
Thyroid has undergone significant changes in its physiological role from lower to higher vertebrates. Its calorogenic role in fish is still disputed. However, it contributes greatly in electrolyte and water balance of fishes. In larval amphibians, it controls metamorphosis and in adult amphibians and reptiles regulates

oxygen consumption at higher temperatures. In birds like mammals it contributes significantly to reproduction and thermogenesis. Extensive work in the past two decades by J. P. Thapliyal, A. Chandola and associates at Banaras Hindu University have provided significant information on thyroid physiology of tropical reptiles and birds. A significant role of thyroid in reptilian reproduction, oxidative metabolism and hibernation has been reported. In addition, role of thyroid in hemopoiesis, intermediary metabolism, thermogenesis and reproduction of migratory and non-migratory birds has been worked out. Recently it was reported that in migratory red headed bunting (*Emberiza bruniceps*), increase in circulating T₃ (determined by RIA) is an important cause of pre-migratory fattening and nocturnal restlessness (zugunruhe)—the two prominent characteristics of migratory disposition in birds.

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SCIENCE SPECTRUM

Archaeology—the science of reading the past

THE objective of an archaeologist is to reveal the whole pattern of human development and evolution of civilization. In this respect the modern archaeologists have taken on something of the questing spirit of science—science to unearth the buried archaeological remains, dating, estimation of age and sex determination in earlier men, environmental studies, etc. To be more precise, what the archaeologist is able to conclude about the past depends to a great extent on the successful completion of these tasks. For this reason they are not content to wait on accidental discoveries or even to dig into monuments merely because they happened to be visible, instead they strive to recover the precise evidence they need wherever this may exist. In this respect the archaeologists are now applying the most sophisticated techniques, viz., magnetic and resistivity surveying for archaeological discoveries.

Magnetic survey

Magnetic surveying is an important and highly developed aspect of geological prospecting. It is a general observation that when a lump of crude clay is heated to a dull red hot state, it acquires a weak permanent magnetism on cooling. This phenomenon is called 'Thermo-remnant magnetism'. Most soil, clay and rocks are expected to contain significant quantities of magnetite and haematite which are iron oxides. They are uniformly dispersed in fine grains. Each

grain of haematite forms a magnetic domain; within a domain the magnetism is uniform. In unbaked clay the domains point in random directions and due to this their magnetic effect cancels out. However, at a high temperature, the intrinsic magnetisation of each domain weakens and some domains are aligned along the lines of force of the earth's magnetic field. After cooling, the domains remain in this lined-up position and, also, the intrinsic domain magnetisation returns to its normal value. As a result, the net magnetic effect is appreciable because of the additive property of the aligned domains.

Acquisition of thermo-remnant magnetism of baked clay is shown in Fig. 1. This thermo-remnant magnetism of a kiln of fired structures distorts the earth's magnetic field from normal in the vicinity of the archaeological features. The deviation from normal of the magnetic intensity is measured using very sensitive measuring instruments such as proton magnetometer, proton gradiometer, etc.

A magnetometer is a simple instrument for comparing magnetic intensities. The proton magnetometer consists of a bottle of water or alcohol around which an electric wire is wound. The magnetic intensity is deduced from the behaviour of the protons which form the nuclei of hydrogen atoms in the liquid of the bottle. The instrument is capable of detecting a change of 1 gamma in the field strength [1 gamma=0.00001 oersted (CGS e.m.u.)].

Magnetic surveying is a useful method of finding kilns as well as in finding pits. There is no known case of a pit going undetected using this technique.

Resistivity survey

Resistivity surveying is another method of detection of buried archaeo-

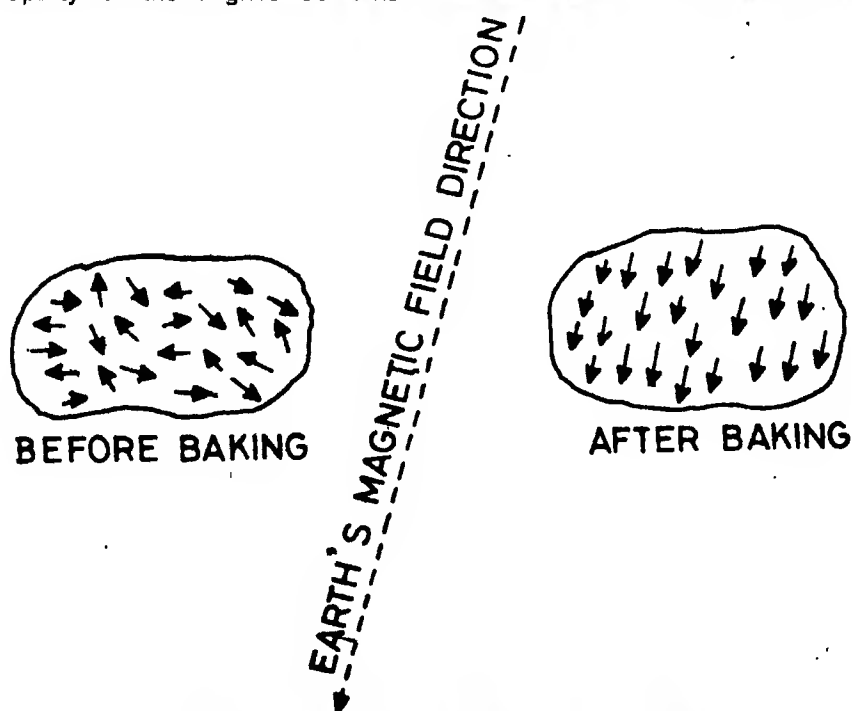


Fig. 1. Thermo-remnant magnetism of baked clay

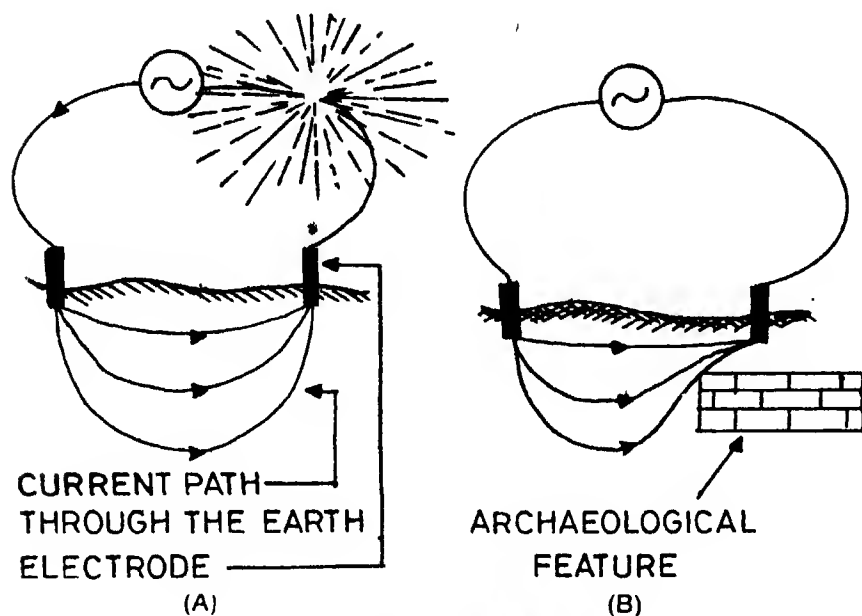


Fig. 2. Distortion of current paths.

logical remains. This is made effective by measuring the electrical resistivity of the soil. Soil resistivity measurement has been used as a geological and civil engineering aid since the second decade of the century, but no one applied it in archaeology until 1946 when R. J. C. Atkinson, a British archaeologist, first used the method in his excavation at Dorchester, Oxfordshire. The technique was tried because of the need to locate as quickly as possible filled in ditches and pits, visible only as crop marks from the air. The success of the method was remarkable and led to its application on other sites.

The principle of soil resistivity measurement is based on its ability to conduct electricity. The electrical conductivity of soil is due to water in the interstices which contain salts dissolved from the material and humic acids of biological origin. Now, if a voltage is applied between two electrodes connected to different points on the mass of soil, electric current will flow between the electrodes. Unlike a wire, the current does not pass straight from electrode to electrode but spreads out into many curving paths through the earth as shown in Fig. 2a. The resultant voltage difference between two inner points is measured by inserting two different probes in-between. The presence of an archaeological sample, being more resistive than normal

soil, causes distortion of the regular current pattern (Fig. 2b) and consequent anomalies in readings from intermediate probes. Based on this principle, some instruments, viz., Megger Earth Tester, Tellohm, etc., have been developed for resistivity surveying.

After detection of the buried archaeological remains, the archaeologist is primarily and specifically concerned with archaeological investigations regarding the time scale of unearthed tools, weapons, utensils, ornaments and human skeletal remains.

Radio-carbon dating

All living matter contains a small but practically constant proportion of the radioactive isotope of carbon, C^{14} , which is produced by cosmic ray bombardment of nitrogen atoms in the outer atmosphere. After the death of an organism, the radioactive carbon in its tissues is no longer replenished from the atmosphere and disintegrates at a constant rate. The quantity is halved in 5600 years. Thus, by measuring the radioactivity of the carbon extracted from an ancient specimen of organic origin its age can be calculated. By this process archaeologists are able to estimate the age of an unknown sample.

This process is, however, not suitable for ageing inanimate objects. So

other methods are suggested for this purpose, viz., thermó-remnant magnetic dating for kilns, technique of thermoluminescence for dating pottery, etc.

Assigning sex

An archaeologist is often confronted with the problem of assigning sex to a bone and the only practical way in which this can be accomplished is by combining measurements and morphological observations in a fashion as logically valid as possible. They mainly depend on some statistical procedures. For example,

A scapula is female if

- (i) the breadth of the glenoid fossa is less than 2.61 mm;
- (ii) the height of the bone is less than 14.4 mm;
- (iii) the length of the spine is less than 127.9 mm; and
- (iv) the weight is less than 38.58 g.

A scapula is male if

- (i) the breadth of the glenoid fossa is greater than 2.68 mm;
- (ii) the height of the bone is greater than 15.75 mm;
- (iii) the length of the spine is greater than 141.4 mm; and
- (iv) the weight is greater than 61.78 g.

(The above data have been taken from Genove's; "Sex Determination in Earlier Man", *Science in Archaeology*, Thames and Hudson.) For verifying sex of archaeological remains, new statistical procedures are being suggested and they are applied to different parts of the skeleton such as skull, sternum, pelvis, etc.

Another important aspect in archaeological investigation is the study of ancient metals. Historical development of human civilization has been standardized in the sequence: Neolithic Age, Bronze Age and Iron Age. But within it our interpretations are constantly shifting. For example, spectroscopic analysis has revealed that in many regions the first use of metal is among cultures generally styled 'Neolithic'; though the metal was copper, not bronze. In this respect, optical spectroscopy reveals many things we would never know merely by looking at them.

sounds generated preceding earthquake seems to be the best possibility, felt the investigators, which was subsequently supported by other independent studies elsewhere. David Hill, a U.S. Geological Survey scientist, says that there are sufficient rumblings and low frequency sounds generated preceding earthquakes. These low frequency sounds (50-70 hertz) similar to thunder can be picked up by animals like pigeons and kangaroo rats, according to Buskirk.

Chance observations in another earthquake in Mogave Desert added credence to this concept of the animal sensitivity to seemingly minor tremors that humans cannot perceive. Most of the aftershocks of the earthquake were simultaneously picked up by dogs with their unusual barkings and seismographs by their whirring. It was only later that the impact was felt by investigator Donald Steirman, awakened by the incessant barking, and checking up for confirmation with the seismograph recordings. Steirman says that some earthquakes may not have appreciable foreshocks but the preceding aftershocks are sufficient to incite anxiety and fear among the more sensitive animals resulting in their unusual attitude. This is confirmed by the chorus of barking of dogs with the whirring of seismographs during the earthquake, he observed.

Research programs on earthquakes predictions correlated to unusual animal behaviour have received a federal support of a mere \$200,000 until last year, according to Jack Everden of the U.S. Geological Survey. This, as he says, is not because of the skepticism about the earthquake-animal interaction but there are not just sufficient numbers of credible research proposals, although a growing segment of scientists is involved in it. Besides, as biologists among the earthquake scientists complain, their physicist colleagues consider animals less appealing than their sophisticated electronic gadgetry for reliability, consistency and handling. But as a scientist puts it, If the machines are ever shown to miss a clue that the uncanny animals are able to pick up there would not be a dearth of physicists to take this seriously.

Seismologists involved in earthquake prediction programmes were under fire recently for an incorrect earthquake prediction, as it occasionally happens. On June 28 last year, an earthquake of 3.0-8.0 on the Richter scale off the Peruvian coast was predicted by Brian Brody of the U.S. Bureau of Mines. Since it was more than 6.5 Richter considered "significant" according to the U.S. Geological Survey definition, the Peruvian government took measures and mobilized the anti-quake machinery into action on a war footing for the earthquake that never came! An embarrassed U.S. Geological Survey's National Earthquake Prediction Evaluation Council expressed an unambiguous regret "that an earthquake prediction based on such speculation and vague evidences has received widespread credence" This has raised

again the vexing question of scientists' responsibility to public information particularly when it concerns someone's pocket book or health. As a leading earthquake scientist, C.B. Raleigh wrote (*Science*, 213 (1981) p. 397): scientists are always under pressure to release observations and conclusions prematurely when the information has direct impact on the lives of public. Since in the litigious American society little allowance is made for human errors, if they have a substantial impact on someone's pocket, he suggests some legal protection against a possible ill-timed or erroneous predictions.

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Does blue light enhance dark respiration?

THERE is no doubt that all living organisms respire and such respiration is associated with the degradation of energy-rich substances via glycolysis and tricarboxylic acid cycle (Krebs cycle), with concomitant formation of "energy currency" called adenosine triphosphate (ATP) by the mitochondrial respiratory chain. The mitochondrial respiration is generally called dark respiration. The quantitative determination of dark respiration can be made on the basis of O_2 uptake or CO_2 output or substrate decrease—all of which are affected by photosynthesis. The problem of quantitative determination of dark respiration could have been tackled with the use of carbon and oxygen isotopes. But such approaches became further complicated because of the existence of light-dependent respiration called photorespiration in green plants. Photorespiration is characterized by the oxidation of photosynthetic by-product glycolate to glyoxylate which is transaminated to glycine. All these reactions occur in a separate organelle called leaf peroxisome. The conversion of glycine to serine and its subsequent decarboxylation takes

place in mitochondria. Photorespiration, therefore, gives rise to O_2 consumption as well as additional production of CO_2 . It becomes apparent, therefore, that determination of dark respiration will be interfered by photorespiration and earlier results on the course of dark respiration in the light appear more or less undependable.

Research reports indicate that photosynthesis greatly influences dark respiration. But some conflicting reports are also encountered. Thus a light-dependent decrease in O_2 consumption has been observed, and interpreted as the result of an inhibition of dark respiration deriving from interactions with photosynthesis. However, experiments with labeled substrates, intermediates of glycolysis and tricarboxylic acid cycle, and specific inhibitors have led to the assumption that glycolysis as well as the tricarboxylic acid cycle may proceed equally well in darkness and in light. Even an enhancement of dark respiration during photosynthesis has also been reported. Thus the matter is far from settled.

The matter is further complicated by the proven existence of two more

light effects on carbohydrate degradation, which appear to be independent of photosynthesis. Inducible by blue light only, they either lead to remarkable enhancement or to an inhibition of substrate oxidation.

Enhancement of dark respiration by blue light

The question whether the influence of light on dark respiration in green organisms is an indirect one coming through photosynthesis or a more direct effect on substrate degradation can be tackled by using cells unable to photosynthesize. Such cells can be obtained from nonphotosynthetic mutants of unicellular green algae or from poisoned tissues unable to photosynthesize or from etiolated (dark grown yellowed) tissues. There are some mutants of unicellular green algae (*Chlorella*, *Scenedesmus* and *Euglena*), which are nonphotosynthetic because of lack of photosynthetic apparatus or photosynthetic pigments. Irradiance of all these permanently or temporarily nonphotosynthesizing cells causes a greater loss of reserve carbohydrates than in darkness. The extra loss is accompanied by an enhanced output of CO_2 by a proportional increased consumption of O_2 . Experiments using various specific inhibitors of glycolysis, Krebs cycle and photorespiration suggest that it is dark respiration which is increased on illumination of the mutant algae. This enhancement (usually 3 to 4 times) is characterized by four distinct properties: (1) a gradual initial period of adjustment, it takes 5 to 10 minutes from the beginning of irradiance until a stabilized enhanced rate is established; (2) a typical wavelength dependence—only wavelengths of the blue part of the visible spectrum are effective with maxima around 460 nm and 370 nm; (3) a low energy requirement; and (4) a gradual decline of the light-enhanced rate in following darkness i.e., after turning the light off, the enhanced O_2 uptake begins to drop immediately. However, it takes several hours before it reaches the low level of a dark control. In green nonphotosynthesizing *Chlorella*, blue light leads to an increase in dark res-

piration. In photosynthesizing *Chlorella* and *Scenedesmus*, an enhancement of dark respiration by blue light has recently been reported. In short, in plants, an additional degradation of carbohydrates takes place even during photosynthesis, and in all probability it is caused by blue light only precluding the possibility of photosynthetic involvement.

Possible mode of action of blue light

The exact mechanism by which blue light acts to increase the degradation of reserve carbohydrates is not known. Several hypotheses have been put forward to explain the mode of action of blue light which may be briefly discussed.

(1) *Influences on ATP levels:* In all cellular synthetic processes, ATP is required. It has been observed that blue light enhances the ATP-consuming synthesis of several nitrogenous substances in the cytosol. The depletion of ATP caused by such synthetic activity in the cytoplasm will speed up the glycolytic glucose degradation via control of allosteric regulatory enzymes (e.g., phosphofructokinase). Experimental evidence in support of this hypothesis is not, however, unequivocal and sometimes conflicting results have been reported. Blue light might also influence intracellular ATP distribution so that the overall amount of ATP determined would not necessarily indicate an increased level at the point of respiratory regulation. It is tempting to speculate that there might be a carotenoid-dependent blue light-driven proton pump generating ATP found in some organisms.

(2) *Influences on respiratory enzymes:* In the nonphotosynthetic mutant of *Chlorella*, blue light has been shown to enhance the turnover rates of several respiratory enzymes such as pyruvate kinase, aldolase, nicotinamide adenine dinucleotide (NAD)—linked isocitrate dehydrogenase and the starch-breaking enzyme amylase. The activity of the enzyme pyruvate kinase increases up to 100% by blue light and this enzyme exhibits a comparably low activity in the dark

and this is predestined to act as a regulatory site in glycolysis. Wavelength and intensity dependencies of the blue light enhancement of its turnover rate coincide nicely with those of increased dark respiration, providing a correlation between both events. However, turnover rate and O_2 uptake rate have not been found to be comparable in many instances. The possibility of modifications of membrane-bound enzymes via structural alterations of the membrane by blue light cannot be ruled out. Some experimental evidence lends support to this hypothesis.

(3) *Influences on intracellular compartmentation:* Some authors assume that the enhanced degradation of carbohydrates under blue light depends on a greater flow of substrate from the storage compartment. In non-photosynthetic *Chlorella* mutant, an enhancement in O_2 consumption is brought about not only by blue light, but also by external application of glucose. It has been shown that the activity of pyruvate kinase is enhanced probably to increase affinity of the enzyme toward phosphoenolpyruvate and *de novo* synthesis of the enzyme. It is postulated that in blue light an increased supply of substrate in the cytosol induces pyruvate kinase biosynthesis, thereby contributing to the total enhancement of dark respiration. The way blue light might act in changing properties of compartmentalizing membranes is far from clear. Because of its wavelength dependence, light-enhanced respiration could be mediated by carotenoids or flavins. A definite conclusion appears impossible as the absorption spectra of both these compounds are very much active.

What is the physiological significance of blue light-enhanced dark respiration?

The actual significance of blue light-enhanced dark respiration is not clearly understood. It may be assumed that there might be some light-dependent regulatory mechanism in green plants that governs the fate of their photosynthetically produced substrates, and a connection between

enhanced dark respiration and the formation of the photosynthetic apparatus. Enhancement of dark respiration is considered a part of a fundamental morphogenetic effect of blue light, and influences on transcription and translation of genetic code are assumed. Besides these, the maintenance of photosynthetic apparatus also appears to require blue irradiation. Blue-green light is known to improve the quantum efficiency of photosynthesis in red light, and the distribution pattern of newly fixed carbon in red or blue light is also different. In red light there is an accumulation of labelled sugar phosphates but there occurs an increase in radioactivity in malate, aspartate, and glutamate (respiratory intermediates) in blue light. Because preillumination with blue light results in comparable changes in fixation products in subsequent darkness or in red light, some light-dependent "conditioning" of the cell for nonphotosynthetic carbon-incorporation appears to be affected by blue light. An indirect effect of blue light on amino acid synthesis has also been indicated. Much work remains

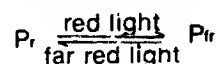
to be done to justify the significance of blue light enhanced dark respiration.

Inhibition of dark respiration by blue light

In addition to enhancement, light, particularly the blue light at high intensity, is known to inhibit O_2 uptake and/or CO_2 output in various organisms. Destruction of cytochromes has been found responsible for the inhibition of dark respiration by blue light. Nothing certain is known about the consequences of this phenomenon. Present suggestions and speculations include mainly morphogenetic effects for enhancing and entrainment of biological rhythms for the inhibitory influence of shortwave visible radiation.

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converted into P_{fr} and by absorbing far red light, P_{fr} is converted into P_r . This reaction can be illustrated by the following equation:



Each form of phytochrome has its own effect on plant development. The red absorbing form causes plants to grow like shaded plants, while the far red absorbing form causes them to grow like plants receiving natural unfiltered light. The proportion of the red and far red light in the incident radiation determines the proportions of P_{fr} and P_r in the plant cell and thereby also the mode of development of the plants.

Although plants keep growing continuously, the magnitude of growth taking place during night is higher than that during daytime. Since there is no light during night, the nocturnal growth and development are regulated by the quality of light received by the plants before the onset of darkness. Thus, if the last light received before nightfall is light transmitted through green leaves, the growth and development occurring during the night are like those of a shaded plant, while, if the last light of the day is that coming directly from the sky, the growth and development during the ensuing night are like those of an unshaded plant. This phenomenon too is governed by phytochrome.

Although, in nature, a young seedling has to compete for light with older plants surrounding it, the competition that occurs in cultivated crop plants is generally among plants of the same age and same species. Therefore, every crop species has its own recommended plant population density. In a crop planted too densely, the plants start shading each other at an early stage and the ensuing competition for light causes them to grow mainly in height, without developing lateral branches or reproductive organs. Such a crop would thus produce mainly stalks and leaves, but hardly any grain or seed. If, on the other hand, the plants in a crop are too far apart, they would not cover the entire area of the field, so that the light

Mutual shading and crop yield

In undisturbed natural habitats, the land is generally covered by a continuous carpet of vegetation so that newly germinated seedlings have to compete with plants that already exist there. Because all green plants need light for carbon assimilation, shaded plants generally increase their rate of growth in an attempt to grow taller than their neighbours. In such plants, most of the available food is used up in the growth of the central axis, causing suppression of lateral branches, flowers and fruits. Readers having experience of gardening may have observed that seedlings growing in shade are tall, but with thin stems and fewer branches, while seedlings receiving full sunshine are relatively short statured, sturdy and with many branches. Although plants receiving more light assimilate more food, the morphological difference in the two categories of plants is not a result of the differential food availability, but the result of a special mechanism

which regulates growth under shade and light.

Light transmitted through a canopy of green leaves is not only weaker, but is also qualitatively different from the natural light above the canopy. Owing to the presence of chlorophyll and carotenoids in green leaves, the canopy absorbs very strongly in the spectral bands lying between 400 and 500 nanometers (blue light) and between 600 and 700 nanometers (red light). All green plants contain in their cells a proteinous pigment called phytochrome, which helps plants in distinguishing between natural sunlight and that transmitted through green leaves. Phytochrome does this by comparing the intensities of red (600 nm to 700 nm) and far red (700 nm to 800 nm) portions of the spectrum with each other. Phytochrome occurs in two interchangeable forms, namely the red light absorbing (P_r) and the far red light absorbing (P_{fr}) ones. By absorbing red light P_r is

would fall on the ground, without being intercepted by the leaves, and would be wasted.

Because plants having thin and narrow leaves intercept less light, plants having such leaves can be planted very densely. Wheat, onion, garlic, sorghum, sugarcane, etc., are therefore generally planted under population densities of more than a hundred thousand plants per hectare. Broad leaf crop species like cotton, sesame, castor, maize, etc., cannot stand such high plant population densities and are therefore grown under plant population densities of much less than 100,000 plants per hectare.

An exception to this general rule is some of the leguminous plants, like soyabean, groundnut phaseolus beans, cowpea etc. In spite of being broad leaf plants, they are regularly planted at population densities of 250,000 plants/ha, and experiments have shown that their seed yield increases with increasing population densities even upto 500,000 plants/ha. Assuming that these plants possess a mechanism for avoiding the ill effects of crowding, a research project was undertaken at this Institute in order to discover this mechanism.

It would be beyond the scope of this article to go into the details of all the experiments undertaken in this connection, but their outcome was the discovery that the nyctinastic leaf movements shown by these plants enable them to survive under such dense stands without suffering the adverse effects of crowding.

Leaf nyctinasty in leguminous plants is manifested by a movement of the leaves, which causes leaf laminae to assume a vertical orientation at or soon after sunset. Actual measurement of light intensity above and below the leaf canopy of a densely grown groundnut crop showed that, during daytime, when the leaf laminae were horizontally oriented, hardly 10% of the incident light reached the ground, whereas, after sunset, when the leaf laminae had assumed a vertical orientation, almost 70% of the incident light could pass unabsorbed through the canopy. It was therefore argued that the nyctinastic leaf movements allowed the last daylight to

penetrate down to all the lower organs of these plants, causing the red absorbing form of phytochrome (Pr) in them to be converted into the far red absorbing form (P_{fr}). As a result of this transformation, the growth and development that take place during the night are like those of unshaded plants. Experiments conducted by the author with artificial sources of light confirmed this hypothesis.

It has already been mentioned above that agriculture generally involves the raising of a single crop

species in a relatively dense stand. Therefore, mechanisms like leaf nyctinasty, which help plants in avoiding unnecessary competition among members of the same species, are of great importance to agricultural scientists. Our Institute is engaged for the last ten years in investigating these phenomena and we have reason to believe that there are still a few more discoveries to be made in this field.

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Sow plants in a pattern for the best use of sunlight

THE radiation from sun is the primary source of energy which sustains organic life on earth. Energy from sun reaches earth in the form of radiation of different wavelengths. Almost 99 per cent of sun's radiation is between 0.15 microns and 4.0 microns known as shortwave radiation. (Table 1)

Ultraviolet (UV) rays are very active chemically and excess exposure to them is detrimental to plants. However, the atmosphere is a regulator. A very small amount of ultraviolet rays normally tolerated by the plants reaches the earth's surface. The part of the spectrum on the opposite side of UV rays is known as infrared and is the longwave radiation. Infrared radiation has thermal effects upon plants. In the presence of water vapour, this radiation does not cause any harm to plants, rather it supplies the neces-

sary thermal energy to plant environment. The middle is the visible part of the spectrum which is light. All plant processes are directly or indirectly

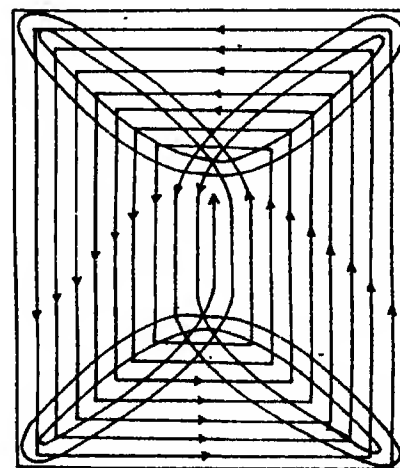


Fig. 1. Round-about method of sowing

Table 1

Spectrum	Wavelength (microns)	% energy
Gamma rays, X-rays and ultraviolet rays	0.005—0.20	0.5
	0.20—0.30	1.5
	0.30—0.40	8.0
Visible rays	0.40—0.50	16.0
	0.50—0.60	13.5
	0.60—0.70	10.5
	0.70—0.92	18.0
Far-red rays	0.70—0.92	18.0
Infra-red rays	0.92—4.00	32.0

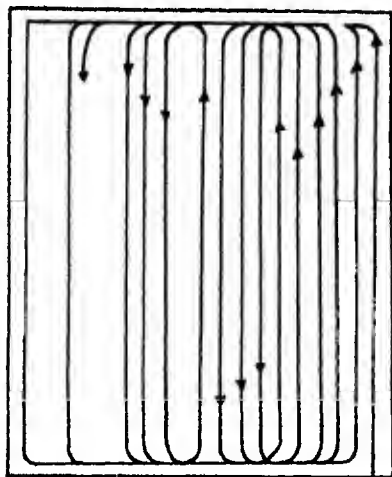


Fig. 2. Uni-directional method of sowing

influenced by this part of the spectrum. The intensity of light is indispensable to photosynthesis. It governs distribution of photosynthates among different organs of the plant. It also affects production of tillers, stability, strength and length of culms, yield and total weight of plant structures and size of leaves and roots. It means visible spectrum is essential for normal growth and development of plants. Because photosynthesis, photoperiodism and phototropism depend upon photochemical reactions carried on by specific plant systems, which respond to different wavelengths, the visible part of the solar spectrum affects plant life directly as compared to other segments of solar spectrum. Photosynthesis is possible only in the presence of sunlight. Further, within this segment of the spectrum, the red, the blue and the violet wavelengths are most assimilable. The green part of light is least important for photosynthesis.

The dry matter of plants is produced through photosynthesis, a process in which carbohydrates are synthesized from carbon dioxide in the presence of solar energy. There are several environmental factors which regulate the rate of photosynthesis. Solar radiation is the most important of these factors. No doubt, it is abundant in India and other tropical countries but its utilization by the crop may become a limiting factor. At the ground level, the final light intensity is usually below compensation point. James Bonner (1962) working at California Institute of Technology,

Pasadena U. S. A., reported that photosynthetic rate of the foliage as a whole continues to increase up to very high light intensities as more leaves in the shaded parts of the crop canopy reach light saturation. In view of this, it should be possible to increase crop yield by facilitating more penetration of sunlight in the crop rows by modifying the crop geometry consistent with solar geometry. Crop geometry can be modified through row orientation, spacing pattern, adjustment of plant population and planting crops on sunny slopes.

Row orientation

Crop sown in north-south rows facilitates greater penetration of photosynthetically active radiation than the one sown in east-west rows. The former pattern illuminates more parts of the plants and causes increased photosynthesis in the entire canopy as stated by Bonner (1962). The increased light penetration/photosynthesis contributes directly to organic pool of plants. Working at Waite Agricultural Research Institute, Adelaide in South Australia, K. Santhirasegaram and J.N. Black (1968) reported that light penetration within the north-south rows was superior to those within east-west rows. Research work done by G.S. Dhillon, Bhupinder Singh and D.S. Kler in 1979 at the Punjab Agricultural University, Ludhiana, also revealed that north-south rows intercepted more light for most part of the day. With north-south direction of rows plants utilize sunlight and moisture fully and are less subject to excessive heat. Crops grown in north-south direction, therefore, give a slightly higher grain yield than those grown in east-west direction. Increase in yield is highly correlated with the interception of solar energy. But even the plants sown in north-south rows do not make the best use of sunlight which is indispensable for plant growth. The plants in the rows get overcrowded and there is competition among them for light. Plants consequently attain more height to get light and there is lot of mutual shading of lower leaves. As a result, they do not photosynthesize fully. Also, light falling in between the

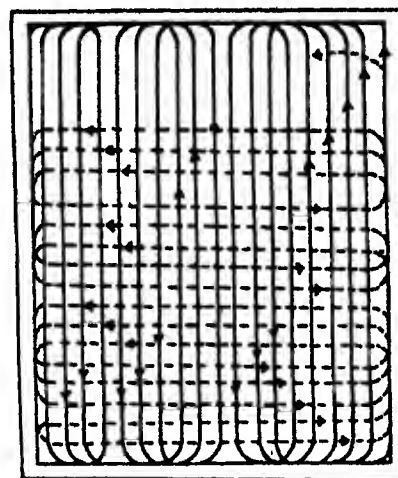


Fig. 3. Bi-directional method of sowing

crop rows is wasted. Besides, plants do not get adequate space for proper tillering. Crop yields are lower than the potential.

The present practice of sowing crops with the round-about method is still more defective. Because, in this method, the rows, in about half the area, are in east-west direction and in the remaining half in the north-south direction. The crop in the east-west rows does not make proper use of sunlight and gives lower yields. In this method, nearly 1/4 area is covered by double sowing while making diagonal furrows where double quantities of seed and fertilizer are put. As a result there is a greater overcrowding of plants in this area, and the plants attain a greater height. Farmers feel happy to see the vigorous vegetative plant growth and think that higher yields are obtained from this area. The reality is that individual plants do not attain proper growth and tillering. The crop lodges and yields low. This results in further lowering the yield of the crop.

Keeping these points in view, experiments were conducted at the Punjab Agricultural University, Ludhiana, for several years to find out the better method of sowing for higher yields. The results show that bi-directional method of sowing (with half the seed rate in one direction and remaining half in the other direction with rows at right angles to each other) has consistently given higher yields. This technology worked well in 17 crops and has given on an aver-



Fig. 4. Bidirectional sowing

age more than 10 per cent increase in wheat yield, 23 per cent increase in hybrid bajra grains, 30.5 per cent increase in yield of gram and lentil, 10-15 per cent increase in oat fodder, 40 per cent in raya, 21 per cent in maize fodder, 24 per cent in sorghum fodder and 18 per cent in bajra fodder.

Bi-directional sowing (cross-sowing) ensures a uniform distribution of plants over a given area and a better establishment of seedlings at an early stage. It helps intercept a greater fraction of light. D.J.C. Friend (1965) while working at Plant Research Institute, Ottawa (Canada), observed that tillering is dependent upon total radiant energy incident upon plants. On the other hand, the sunlight that falls in between the rows in uni-directional sowing, particularly at early growth stage, is wasted. Research work done in the Department of Agronomy at Punjab Agricultural University, Ludhiana, by D.S. Grewal (1982) showed that light interception, being a function of plant population and plant growth, bi-directional sowing leads to increased interception of light at later stages of crop growth. Increased grain yield in bi-directional sowing is the result of uniform distribution of plants in a systematic manner, ensuring efficient use of soil moisture, nutrients and solar energy.

Research conducted by Texas Agricultural Experiment Station along with Soil and Water Conservation Division, United States Department of Agriculture by K.B. Porter, M.E. Jensen and W.H. Sletten (1960) also advocated the need for uniform distribution of crop plants. Less interception of light by the uni-directional sowing leads to relatively more light penetration in crop rows which raises temperature near the ground level. This further enhances photorespiration/negative contribution in lower

leaves during day time. Grain and straw yield is decreased. During night hours, the thick crop canopy of bi-directionally sown crop saves crop from adverse effects of low temperature. The crop makes efficient utilization of microenvironment. Significant lower incidence of powdery mildew and brown rust was recorded in bi-directionally sown wheat at Punjab Agricultural University by D.S. Grewal (1982). The reason could be that in such crop canopy, the relatively lower movement of wind might have checked the conidia from being spread fast. More relative humidity in the bi-directionally sown wheat also checks the release of conidia from postulates. Higher interception of light by the bi-directionally sown crop could also have a detrimental effect on pathogens. This explanation seems to be more valid from the point of lower incidence of powdery mildew on upper leaves which are fully exposed to sunlight.

Working at Graham Experiment Station at Michigan (U.S.A.), T.B. Sutton, A.L. Jones and L.N. Nelson (1976) reported that release of conidia is negatively correlated with relative humidity and leaf wetness. Infection of wheat with puccinia rusts is known to increase under low light intensity. This was recorded at Institute of Phytopathological Research, Wageningen in Netherlands by R.W. Stubbs in 1967. Research work done at Punjab Agricultural University, Ludhiana,



Fig. 5.

showed that although the number of weeds was not affected by bi-directional sowing, their dry weight was reduced. Smothering effect of bi-directional sowing on weeds seems due to increased competition because of higher plant population and unavailability of sunlight beneath the canopy. Weeds which germinate at later stages of growth cannot get sufficient light under a crop canopy causing weak growth and lower dry weight

Row spacing

Crop geometry can also be modified to changing row to row spacing. Because, with a given number of seeds per unit area uniform distribution of plants can be achieved by decreasing row spacing. This has been shown practically in German Federal Republic by G. Mülle and H. J. Heege (1982)

Adjustment of plant population

Proper population of plants adjusted in a systematic manner in a field is necessary for efficient utilization of solar energy. In a very thin stand light energy that falls on bare soil is wasted. On the other hand, in an excessively thick stand, lower leaves of plants fail to get adequate light for photosynthesis because of mutual shading. Lower leaves are generally older with a lower photosynthetic capacity. Under low light intensity in a thicker stand, they become a drag on the plant due to loss of photosynthates in respiration causing poor grain yield per plant. For higher grain yield, it is necessary that optimum population of plants be uniformly distributed over a unit area

Planting crops on sunny slopes

Light trapping is of prime importance in temperate climates where growing period is comparatively shorter. In such areas it can be made feasible by taking into account solar angle. By proper slope in a particular direction, flow of solar radiation or light intensity can be increased. It can be done in the northern hemisphere by planting crops on southern slopes of

east-west rows. The method is practised in winter to get early crop of vegetables

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Genetic control of insects

INDISCRIMINATE and persistent use of chemicals to control pest population cannot be considered ideal for two main reasons. One, they contaminate the abiotic components of ecosystem and thereby biotic components through their passage from one individual to another in a food chain including man and, two, high incidence of resistance against the conventional chemicals, viz., organochlorine and carbamates. Although they cannot be dispensed with, there is need for alternatives. The genetical method aimed at producing reproductive failure or at replacing the harmful by a harmless insect population seems to offer the greatest potential.

Sterile insect technique

Insects can be sterilized by irradiation or by exposure to chemosterilants. The purpose of such treatments is to induce dominant lethal mutations in the gamete chromosomes which, when combined with those of the wild individuals, produce lethal effects in developing embryos. When sterile males are released, the greatest effect on reproduction will be in those insect populations in which the females mate only once. In such cases a wild female mated with the sterile male will not subsequently mate with a fertile male and will lay only sterile eggs.

The choice of male insects for sterilization and their subsequent release is based on the fact that the males usually play a less important role in transmission of human or animal diseases (tse-tse flies are an exception in which both males and females suck blood and transmit trypanosomiasis). Males are also preferred because they disperse more and mate more than once. Therefore, the sex separation

technique is a usual requirement for large scale sterile insect release schemes.

Sterilization by irradiation

For mass sterilization of insects the irradiation source should be of such a size as to permit exposure of a large number of insects in the shortest possible time. Gamma irradiators are almost universally used. Now-a-days compact, easy to transport sources are also available which are expensive, but last for a long time (^{60}Co has a half-life of 6 years and ^{137}Cs one of 30 years) and involve little or no risk in their use. In most insects, it appears that the minimum irradiation dosage required to sterilize males also sterilizes females. This could be of advantage where sex-separation is difficult. The screw-worm eradication campaign in the US is still remembered as one big success in the use of irradiated insects. In recent years, small-scale success has been achieved in employing this technique against desired species in different parts of the world.

Among the insects of public health importance, some attempts have been made to control the housefly (*Musca domestica*) and the blowfly (*Lucilia sericata*) by the release of irradiated males but without much success. It has been estimated that normal males successfully copulate 6-12 times while the sterile males are capable of copulating only once and this does not necessarily prevent the female from subsequently accepting a normal male, or from producing viable offspring. An attempt to control mosquito *Culex pipiens fatigans* in India by the release of 24,000 males irradiated at 7,700 rad over a period of 35 days resulted in only 6% reduction in the hatching of egg rafts.

Sterilization by chemosterilants

Chemosterilants (chemical sterilizing agents) are relatively cheaper though they sometimes cause toxic hazards to man and his environment (they can be both mutagenic and carcinogenic) at higher doses. Being toxic to all living organisms, they cannot be used in large-scale field applications. Their ideal method of use is in combination with an efficient insect-specific attractant. Such a method can do away with the necessity of having a factory source of insects and special sterilization release procedures. Unlike radiation, chemosterilants seem to have less effect on the female than on the male insect. This technique was employed to control cotton boll weevils in the U.S.A. but the achievements have never been very high.

Hybrid sterility

Hybrid sterility, a well-known biological phenomenon, is the result of crossing two closely related species. Such hybrids in addition to being sterile may show differences in such characters as enhanced size, longevity and even sexual activity. The strength and stamina of the mule are well-known. What is perhaps less known is the sexual aggressiveness of this animal which compels breeders to isolate it from the parent stocks of horses and donkeys.

Such a combination of male hybrid sterility and vigour has been found to result from crosses between 5 sibling species of the *Anopheles gambiae* complex, some of which form the main malaria vectors of Africa. The possibility of genetic control by sterile hybrids is also being investigated in *A. punctulatus* in different countries.

Cytoplasmic incompatibility

Within some insect species, e.g., *Culex pipiens*, crosses between various populations are sterile. Sterility is considered to be due to a cytoplasmic factor transmitted through the egg which kills the sperm of the incompatible male after its entry into egg. Between some populations, sterility results in both directions, while

in others it is seen in one cross but not in the reciprocal. Thus a potential exists for control by the mass rearing and release of male population in an area populated by incompatible crossing types. Desirable genetic traits can be introduced into an incompatible strain without changing the incompatibility and so strains from temperate regions can be adopted to tropical environments.

Translocations

A common consequence of irradiation of cells is chromosomal breakage. If this occurs in two non-homologous chromosomes in the same cell, and the broken pieces get attached to the wrong partners, the reciprocal translocations result in the production of a proportion of unbalanced gametes without a complete genetic complement. When these gametes fertilize normal gametes, nonviable embryos are produced. For a single translocation, such semisterility is usually inherited by one half of the progeny of a heterozygous normal mating. If an individual inherits the same translocation from both parents, it becomes a translocation homozygote and may be normally fertile and viable (though most of them probably will not be so). The possibility therefore exists of isolating such a homozygote, breeding it on a large scale and releasing it into a wild population.

A special type of translocation, a compound chromosome, is known in fruitfly (*Drosophila melanogaster*)

and involves the exchange of whole chromosome arms between a homologous pair. Mosquitoes are considered good potential candidates for the isolation of such chromosomal exchanges. Compound chromosome strains breed true and are fully viable though their fertility is only 25% to 50% of the wild type. When individuals carrying compound chromosome mate with the wild type, however, no viable offsprings are produced. The hybrids die in the embryonic stage. Theoretically, if the compound strain is released into a wild population in excess of 4 times the number of the latter, it should replace the latter within a small number of generations. It would be an ideal transport mechanism for introducing conditional lethals (temperature sensitive or insecticide-susceptible genes) or other genes advantageous to man.

In all the genetic methods discussed above, such mechanisms as meiotic drive, sex distorters and species competition exist, but they remain to be convincingly demonstrated as practical methods. Man's ingenuity has been challenged and the challenge is being met. Whether nature will produce some resistance mechanism to such novel developments remains to be seen.

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Insecticidal principles in chrysanthemum

CERTAIN flowers develop some substances in self-defence. These substances are generally insecticidal and protect the beauty and scent of the showy flowers. Pyrethrum which has been found to possess insecticidal principles is obtained from the floral heads of some members of *Chrysanthemum*, viz., *C. cinerariaefolium* Vis. and *C. santhemum coccineum* Willd., etc. That certain types of *Chrysanthemum* do have strong disinfectant ability remained a business secret known only to restricted people in Germany who imported the

powder of the *Chrysanthemum* head bearing "Persian Insect Powder" as the trade name. The powder was used for quite a long time in controlling bed bugs, bees, flies, etc. It was after the 2nd World War that the trade of pyrethrum spread to other countries like USA, Japan and Kenya which remained the chief supplier of pyrethrum as the pyrethrum flowers were grown in steadily increasing scale there.

The insecticidal factors are confined only to the flower heads and that before the appearance of the inflores-

cences, roots, stems and leaves were devoid of insecticidal materials. The flower heads consisted more than 90% of the insecticidal principles. Flower heads are plucked at a stage when the centrally located florets start to open. These flowers are artificially dried (49°C–54.5°C) and baled for commercial purposes.

The active principles

The active principles behind the insecticidal properties of the *Chrysanthemum* flowers came to recognition in late fifties of the present century. It was found that a resin-like toxic substance is responsible for the insecticidal properties of the flowers and this substance was found to be a mixture of esters. They fell under four categories:

(i) *Chrysanthemum monocarbox-*

yllic acid, ester of pyrethrolone, called, Pyrethrin I.

(ii) *Chrysanthemum monocarboxylic acid*, ester of cinerolone, called, Cinerin I.

(iii) *Chrysanthemum dicarboxylic acid*, ester of Pyrethrolone called Pyrethrin II.

(iv) *Chrysanthemum dicarboxylic acid*, ester of cinerolone called Cinerin II.

In recent years attempts have been made to search out more, wild germ-plasms of *Chrysanthemum* and to establish newer varieties keeping in mind not only the beauty and weight of flowers but also the amount of the insecticidal principles they possess.

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Wasp stinging and venoms of wasps

MOST of the nineteen species of the genus *Vespa* occur in Indo-Australian archipelago. Amongst the species reported from India—*Vespa orientalis*, *Vespa tropica*, *Vespa affinis*, *Vespa basalis*, *Vespa mandarina*—the last one is commonly distributed and easily distinguishable from others by its gigantic size, the deeply incised clypeus and the enormously developed genae (Fig. 1). Its body weight is almost twice that of other species. (True wasps comprise only the families Masaridae, Eumenidae and Vespidae; to the latter family belong the species of subsocial and social wasps.)

Wasps, in general, exhibit certain interesting aspects of stinging. Generally a wasp 'guard' is at the nest entrance with its head facing outwards. The common task of such sentries is to keep an eye on the incoming and outgoing traffic. In case of any danger or an attack on the nest, the 'watchman' alerts other wasp workers inside by ejecting a drop of venom. The venom contains certain volatile substances called 'alarm substances' the odour of which apparently serves to warn other members.

Another common feature found in various wasp species is the foraging behaviour. The foraging distance determined in various species by employing metal labels revealed that about 80% of the workers foraged within 335m from the nest. Besides the insect and other arthropod bodies which served as protein source, wasps also visit butcher shops and fish markets. Many have observed their attacks on beehives which lead to extermination of the bee colonies. The attacks on bees are very systematic and occur in following steps: a hunting phase which involves visiting a beehive, lying in wait, catching a bee and carrying it to a nest; the second, a slaughter phase in which the wasps kill the bees at the entrance and the slaughter continues till most of the bee population is terminated. In the invasion phase, wasps forcefully enter the hives and seize the pupae for food. This tendency often poses problems for the bee keepers.

In contrast to this, wasps show markedly different reactions to disturbances of their nests. They savagely attack intruders close to the colony entrance. The wasps immediately respond to a disturbance to

the nest structure. Alarmed wasps rush out; once the intruder is located the closest wasp starts stinging, the others also try to sting. This is due to the presence of volatile substances in the venom which act as an indicator for other wasps.

Instances of wasp stinging have been recorded all over the world ever since the Biblical times. Clinical manifestations of Vespidae sting are now well-known and depend mainly on 1. the species of the stinging wasp, 2. the depth of the sting, 3. localisation of the sting, 4. number of stings received, and 5. the sensitivity of the victim. Local symptoms include acute pain, edema and rise in temperature at the site of the sting. Hemorrhage and formation of papulae at the sting site may also occur. Unusual swelling at this place may persist for several days and spread to adjacent areas. Generalised symptoms as a result of systemic effects are mostly related to the toxic action of various venom components. Cytolytic, hemolytic, neurotoxic and hemorrhagic action may be observed. Lowering in blood pressure, bronchospasm, hemoglobinuria, paralytic and hemiplegic syndromes have also been noticed after a wasp sting. In some cases, secondary infections have also been noticed to follow because of the scavenging



Fig. 1. *Vespa mandarina*

nature of the wasps and consequently greater chances of bacterial contamination. Even some protein allergens have been found to be responsible for sensitisation as fractions of wasp venoms, separated by chromatographical techniques, were seen as active components in various skin tests.

The components of wasp venom known to cause such toxic actions are many and include low molecular weight substances such as acetylcholine, histamine, serotonin, catecholamine, kinin as well as high molecular weight proteins mainly enzymes like cholinesterase, phospholipases, hyaluronidase, proteases, poly- and disaccharidases, etc.

The amount of acetylcholine found in species like *V. orientalis* is quite high. However, the origin of acetylcholine in wasp venom is not understood. It is not yet clear whether the venom gland possesses choline acetyltransferase activity responsible for acetylcholine synthesis. Histamine also occurs in extremely high concentrations. Its presence in venom probably must have been designed by nature to victimise primarily arthropods rather than human beings. In the latter, histamine contributes exten-

sively to cause painful reaction and local vasodilation. With regard to serotonin, there is a total lack of knowledge concerning its synthesis and metabolism; probably this amine promotes intracellular penetration of the venom by increasing cell permeability. Catecholamines (dopamine, noradrenaline, adrenaline) are comparatively a recent discovery in wasp venom components, their concentrations vary rather unevenly among different wasp species. There are suggestions that catecholamines ensure a rapid spreading of other toxic components of the venom after the sting. There are also postulations that these substances bring about local vasoconstriction and concomitant reduction of local blood flow which prevents rapid destruction of other venom allergens by the host enzymes.

Amongst the high molecular weight substances—phospholipases have been studied extensively. Their pharmacological effects include *in vitro* and *in vivo* hemolysis, liberation of biologically active substances, lowering of blood pressure, etc. One can also envisage their contributory role in disruption of neuromuscular transmission. Concerning the role of hya-

luronidase, it has been considered responsible for spreading of venom through depolarisation of mucopolysaccharides in and around the site of the sting. Wasp venom proteases are also assumed to be capable of splitting—a wide range of substrates, considering the role of venom to the victim's proteinic tissue.

Summarising, the overall pharmacological effects of wasp venom after the sting can be related to:

1. Cardiovascular system (hypotension, hemolysis, hyperglycemia, increase in permeability of microvascular vessels, anticoagulant activity etc.);
2. Respiratory system (bronchoconstrictive, respiratory arrest);
3. Striated muscle (paralysis); and
4. Vision system (ocular irritation).

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2. An autobiographical essay, one or two pages long;
3. A clear statement of purpose as to why you are interested in coming here (this should be in about 250 words);
4. A choice of dates; indicate a continuous period of six weeks between 1st May and 31st July, 1985 which would suit you (give one or two alternatives, because a hostel room may not always be available; if you do not need accommodation, say so).

The envelope should have the words 'Molecular Biology Summer Programme' clearly written on the outside. In addition, request two persons who are acquainted with you academically to send letters of recommendation in a similarly superscribed envelope directly to the above address, also before February 28, 1985. Selected candidates will be informed individually. During the period of their stay here, they will be paid a stipend of Rs. 500/- per month, return second class rail fare from their place of residence, and, if they want it, will be provided hostel accommodation at their own cost (this will work out to about Rs. 150/- a month or less).



MEDICAL NOTES

High consumption of animal protein and fat may lead to colon cancer

EPEDEMOLOGICAL study suggests that the development of human colon cancer is associated with high consumption of animal fat and protein, especially beef which forms a large part of western diet. Indeed colon cancer is prevalent in North America and Western Europe but not in Japan. A balanced western style diet contains, in addition to meat, side dishes of bread and vegetables and fruit juices. A typical Japanese diet on the other hand consists of boiled rice and dishes of fish and vegetables and soup. Both diets supply large amounts of inorganic nitrates.

Some associations between the endogenous formation of nitrosamines and colon cancer have been suggested, although the specific carcinogen involved remains to be identified. Nitrosamines are potent carcinogenic chemicals that form in the alimentary canal from precursors such as nitrates contained in meat and vegetables, and secondary amines which originate from amino acids largely present in meat.

In a recent article (*Nature*) K. Suzuki and T. Mitsuoka of Japan have reported that levels of certain volatile nitrosamines in human faeces are markedly increased in Japanese individuals given a western-style diet, but decreased by a typical Japanese diet. The balanced western-style diet provided 25% protein (mostly derived from meat), 55% fat and 20% carbohydrate, while the typical Japanese diet had 15% protein (mostly from cereal), 20% fat and 65% carbohydrate.

It was found that levels of nitrosam-

ines fluctuate with a change in diet. The presence of nitrosamine precursors in the diet is by far the most important contributory factor. Sufficient quantities of nitrates, amino acids and lipids, such as in balanced western-style diet, contribute largely to the formation of nitrosamines in the intestine.

Though both the balanced western-style diet and typical Japanese diet were nutritionally adequate, they differed in their contents of proteins and fats. The fact that the average level of total volatile nitrosamines in faeces in the case of balanced western-style diet was ten times that in faeces from those given the typical Japanese diet may have strong implications in the etiology of colon cancer.

One important fact which emerges

from this study is that high nitrate content of the diet accompanied by high animal protein and fat can lead to formation of carcinogenic nitrosamines in human intestine. This can predispose a condition suitable for development of colon cancer. The Indian diet is typically vegetarian (60%) and low in animal protein (40%). Nitrate is chiefly contained in vegetables. Although intake by an average Indian may be high, our low animal protein intake may not favour formation of intestinal nitrosamines. This may be one reason why incidence of colon in India is low (but it has recently increased by 2%-8%).

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Role of vanadium in glaucoma and cataract

VANADIUM is a ubiquitous element present in the earth's crust, sea water, oil and tissues of man and animals. Vanadium is an essential trace element whose deficiency leads to reduced growth, increased plasma cholesterol and poor bone development. Vanadium has toxic effects too, which cause in several types of disorders including vomiting, diarrhoea as well as respiratory paralysis.

Humans consume 2mgm-5mgm of vanadium daily through gelatin, cereals, sea food, vegetables and oils. It has been experimentally confirmed that oral dose of vanadium up to 25 mg per day does not induce any toxic effect. Most of the consumed vanadium is excreted through urine and faeces with only about 10% being retained, mainly in bones. Much earlier, during the end of 19th century, vanadate was used in France as a general tonic to cure heart disease, tuberculosis, syphilis, rheumatism, diabetes and arthritis.

Unfortunately no serious consideration was given to the biological and biochemical significance of vanadium until it was recognised recently to be present as an impurity in preparation of adenosine triphosphate (ATP) from rabbit or equine muscle.

ATP is a potent inhibitor of membrane's sodium-potassium-dependent adenosine triphosphatase (NaKATPase). Thus vanadium has been found to inhibit several ATPases, acid and alkaline phosphatases, phosphofructokinase and adenylate kinase. In addition, vanadium stimulates glucose oxidation and transport in adipocytes. Besides, it increases glycogen synthesis in the liver and inhibits intestinal glucose transport.

Vanadium exists as vanadate (H_2VO_4^- in dilute solutions at neutral pH which polymerises at concentrations above 0.1 mM. Vanadate enters human red blood cells by anion transport mechanism and is reduced to vanadyl ions (VO^{2+}) inside the cells. Vanadyl ions are bound to proteins. Both vanadate and vanadyl ions have different biological significance since vanadyl ions are powerful inhibitors of alkaline phosphatase with no inhibitory effect on NaKATPase.

Recently, it has been reported that the topical administrations of vanadate (1%) reduces intra-ocular pressure in rabbit eye by about 30%. Significant reduction in intra-ocular pressure has also been obtained in rhesus monkey eyes following topical vanadate. Systemically administered

vanadate has no such effect.

The new role of vanadate in inhibiting NaKATPase may have useful as well as toxic action on the eyes. It is useful because NaKATPase in the ciliary epithelium plays a major role in the formation of aqueous humour and thus the inhibition of NaKATPase can be considered as a reasonable working hypothesis for the mechanism by which vanadate can lower intraocular pressure in glaucomatous eyes. Likewise, the role of vanadate can be toxic since the lens epithelium possesses effective NaKATPase and its inhibition can lead to the destruction of lens metabolism leading eventually to the formation of cataracts.

The inhibition of NaKATPase by

vanadate is prevented or even reversed by catecholamines and ascorbate. Catecholamines reduce vanadate to vanadyl which is marked by the formation of black precipitate. Ascorbate also reduces vanadate but this is of particular importance in case of man, monkey and guinea pigs who are incapable of synthesizing ascorbic acid. In such a situation, the effect of vanadate or NaKATPase of the ciliary epithelium will depend on the accumulation of dietary ascorbate and its transport into the ocular fluids.

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Sperm Immobilising protein as a contraceptive

SPERMS are formed in the seminiferous tubules, which drain through a network of ducts into the epididymis. Newly formed sperms in mammals develop the ability of swimming only after they have passed down the long, coiled epididymis to collect in the tail of the epididymis. However in many species, even the spermatozoa in the caudal region of the epididymis are immotile until after

ejaculation. There are several theories to explain the mechanism of initiation of sperm motility at this stage—usually complex and involving subtle changes such as concentrations of sodium ions.

Recently two U.S. scientists have come up with a very simple answer which has the additional attraction of the clinical potential as a barrier (local) contraceptive. Marion Ussel-

man and Richard Cone of Johns Hopkins university in Maryland have detected a glycoprotein which immobilise the sperms and has been named "immobilin" by these workers. [Usselman M. & Cone R, *Biol. of Reproduction*, 29:1241]. Immobilin is a large glycoprotein present in the fluid in the caudal epididymis of rats which apparently increases the viscosity of the fluid beyond the point where sperm can swim. Other motile cells such as rabbit sperm or the bacterium *E. coli* were also unable to move, if placed in the fluid from the tail of the epididymis of rats.

Since sperm motility is a factor in human infertility (normal human sperms move at a speed of about 3mm/min through female genital tract, and at least 15 motile sperms per high power field should be seen in the post-coital cervical mucus), this finding may have clinical applications. If immobilin is found in female genital tract, it may explain some cases of infertility or sub-fertility. Also, immobilin may be useful, perhaps along with other methods of contraception, as a mechanical or local method to reduce sperm motility and thus may have some promise as a contraceptive.

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SCIENCE FOR THE YOUNG

The fascinating geckos

LIZARDS have undergone an extensive adaptive transformation and taken on a bewildering variety of habitats. Of these, geckos form a unique family with a definite claim to some outstanding features. They have a stentorian voice to match the calling notes of frogs and birds and possess "climbing" feet that enable them to crawl upon ceilings and barks. Most geckos are stoutly built, short-tailed, largely nocturnal and partly diurnal creatures.

Found everywhere barring the high altitudes, they are most numerous in the Australian and Oriental regions. All geckos are not wall lizards. Some four hundred kinds of them are found throughout the world—in the desert, in the open and wooded country and a few having a strong predilection to domicile with man. They vary in size from 4.7 cm long *Sphaerodactylus* of America—perhaps the tiniest in the whole lizard clan—to 35.5 cm giant, Tokay of southeast Asia. Geckos have been transported by man from continent to continent which explains their world-wide prevalence.

Appearance

The body of a gecko is covered with small, granular scales or tubercles. The skin is very thin and some forms appear almost translucent in strong light. The tail is a diminutive, stumpy appendage presenting the greatest diversity of form. It is usually cylindrical tapering to a point. But in certain

desert living forms, the tail is swollen and probably serves as a food reservoir. Few lizards can compete with

geckos in their ability to discard the tail. An adult gecko with the original tail intact is rarely found. When gripped by the tail or trod upon, geckos make good their escape leaving the broken bit of the tail wriggling. Nature takes care of this damage; a new tail is grown out within two months from wounds which fail to break off the original. So this process of partial loss, regrowth, and healing results occasionally in a two or more tailed geckos. Majority of the geckos have immovable eyelids. Instead, their eyes are covered by large, fixed, transparent "spectacles" beneath which the eye can be moved. Geckos that are active by day have rounded pupils and the rest have an elliptical pupil as an indication of their activities in night.



Fig. 1. The common wall lizard of India (*Hemidactylus brooki*)



Fig. 2. The fat-tailed desert gecko (*Eublepharis macularius*)

Food

Geckos have a thick fleshy tongue employed in the same fashion as that of a toad's in lapping up their main food—small insects. The tongue is capable of considerable protrusion though it is hardly used as an organ of investigation. While the smaller prey is lapped up by the sticky tongue at a stroke, the gecko has to put in considerable effort in seizing larger insects like cockroaches which are approached in a series of swift rushes with a rest after each. Water is consumed by lapping it up with the tongue. As their requirement of water is minimal, geckos, like other reptiles, can thrive in arid tracts. Geckos relish sugar syrups and rice in addition to their usual food. A bottle of syrup kept in a dark corner of the house is an effective trap for geckos. Geckos can survive without food for months and, when it is scarce, large males and females may bite off and eat the tails of smaller geckos and even devour young ones whole. Sometimes the cast away skin is also swallowed.

Behaviour

Male geckos are usually larger, heavier and more quarrelsome than females. Further, males tend to hold their hunting territories very possessively. When a male gecko encroaches upon its neighbour's preserve, a fight ensues resulting in the two combatants holding each other by the head or body and biting and struggling until one is finally exhausted and retreats. The presence of a row of small, brownish or reddish spots called femoral glands on the thighs of a gecko indicates that it is a male. It is believed that these organs keep the

cloacal region of the males intact on the belly of the female during coition.

Clinging pads

The capability of our house geckos to run over a window pane or up a smooth vertical wall and across the ceiling with the sure footedness of a cat amazes all of us when we watch them in their "beats" commencing as soon as night falls. The secret lies in the microscopic hooks arranged fan-wise on the underside of a gecko's toe which can hook on to irregularities on vertical surfaces as smooth as glass. Broadly speaking, a gecko can cling to all but the most highly polished surface. In addition to the adhesive pads of their feet, most geckos have the usual claw at the toe-tips which also aid in negotiating a firm grip for the animals. The fact that this unique adhesive mechanism of geckos does not function on moist surfaces is little known. As such geckos fall down

uninjured and alive if water is squirted on them.

Voice

Another distinctive feature of geckos is that they are capable of producing sounds and it appears they can hear well. While most lizards are silent creatures barring the emission of angry hissing sounds, the geckos are remarkably vocal—hence their popular names 'gecko', 'chipkali', or 'chiplee'. A gecko produces this unusual sound by clicking its broad tongue against the roof of the mouth and usually it is a soft chirruping or clucking sound. The loudest call among the geckos is credited to the Tokay which can be heard even 91.5m away in an undisturbed area. Some geckos are reported to reproduce sharp sounds by rubbing certain plated of their tails.

Young

Barring the geckos of New Zealand which bear living young, the rest lay 2-3 white, oval hard-shelled eggs instead of leathery ones as is the case with most of the lizards. Geckos do not bury their eggs but lay them in the crevices of trees, rocks or even in such unusual places as radio or TV sets, bookshelves, wardrobes, etc. The tree-dwelling geckos glue their eggs to the underside of a leaf or bark of a tree. It takes about two months for the eggs to hatch into exact replicas of their parents.



Fig. 3. The Andaman Green gecko (*Phelsuma andamanense*)



Fig. 4. The blotched house gecko (*Hemidactylus triedrus*)

Giant

Tokay of Asia, named after its guttural rumble "touk-tay", is a giant among geckos of the world as it grows up to nearly 46 cm. It can bark and bite like a dog.

Hiding by day in holes or crevices near the ceilings, this lizard with its rat-like body, a pulsating throat and glittering cat-like eyes in the night is no stranger to the people of north-eastern India. This red or orange spotted house lizard is not contented only with preying on insects but occasionally gulps down a small rat, bird, bat or a snake in its nocturnal rounds. While most geckos are gentle and inoffensive, the Tokay is an exception. When annoyed it inflates its body and hisses and puffs loudly, holding its jaws wide open in readiness to attack. If the provocation continues, the lizard rushes forward and seizes some part of the anatomy of its annoyer in its extremely powerful jaws, hanging on with bulldog tenacity. Sometimes it gets involved in long drawn combats with larger snakes for hours. The battle, however, ends with the snake coming out victoriously after thoroughly exhausting the lizard.

Other geckos of India

Geckos constitute a major component in the lizard fauna of India accounting for more than one third of

the 150 Indian species. Among the house geckos are the spotted house-gecko (*Hemidactylus brooki*), the yellow bellied gecko (*Hemidactylus flaviviridis*), and the bark or tree-gecko (*H. leschnaulti*). While the spotted gecko is often found far away from buildings, tree-gecko finds better shelter and food in the houses also. The rock-geckos (*Cyrtodactylus*) have clawed toes and laterally compressed bodies. The fat-tailed gecko (*Eublepharis macularius*) inhabiting arid areas of north-western India is a ground dweller and strictly nocturnal. Its movements are slow and it walks often with the body well off the ground. When annoyed, it opens its mouth, raises its tail and bites readily. But for this typical reptilian type of defence, it is harmless however much it is dreaded by the desert people who regard its bite as highly poisonous and its body fluid as lethal on contact. Indeed there are no venomous lizards in India or for that matter anywhere else except in U.S.A. and Mexico. The fat-tailed lizard differs from all other geckos in having the true eyelids and a carrot-like tail. It is a voracious feeder and its diet includes crickets, spiders, scorpions and even other lizards. The Andaman and Nicobar Islands are the home for two unique Oriental geckos—the "flying gecko" (*Ptychozoon kuhli*) of the forests of Nicobar which can parachute to small distances by means of

the membranous expansions on the sides of the animal's body, limbs and tail and the Green gecko (*Phelsuma andamanense*) of Andamans which is not uncommon in and around Port Blair. Several geckos (*Cnemaspis*) are restricted to the hilly regions of South India.

Benificial

Geckos are harmless and the smaller species never make an attempt to bite and even if they do, their feeble jaws are incapable of inflicting any injury. They are, however, accused of tainting our food and water in the kitchen. Also, geckos are prone to bacterial infection and there are cases of such infested geckos falling accidentally into the cooked foods. Those who may partake of such foods may develop temporary nausea but never fall seriously ill or die as often alleged.

Superstitions about geckos are as widespread as geckos. The unreasoning fear that the geckos are deadly venomous, poisoning every part of human or object over which they run or accidentally fall upon strangely enough persists throughout the world. On the other hand, the bark of a Tokay soon after a child's birth in a Malaysian house is welcome and considered indeed very auspicious since it is a harbinger of good luck to the newly born.

Despite their abundance, geckos evoke no popular response in man. Most house geckos can be easily tamed and learn to take food from our hands. The fat-tailed lizard is not at all venomous but makes an excellent animal for terrarium. The presence of geckos in our houses is to our advantage as they are considered as efficient as birds in keeping down harmful and undesirable insect pests.

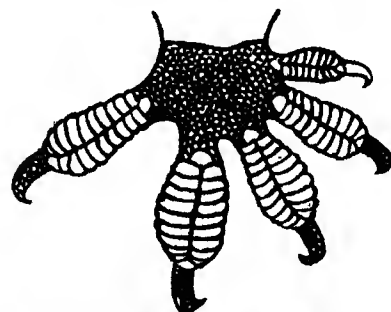


Fig. 5. The clinging foot of a wall lizard

It is time we gave up the intensive dislike for any creature called reptile and understand their beneficial role in nature. We are slow to recognise our debt to the geckos.

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Miniature circuit breaker and its application

If you look at the electric wiring circuit in your house, you will find that for controlling electric power flow to a lamp or fan, there are 'ON' and 'OFF' switches. Behind this switch in the circuit, there is a sheet steel box called distribution box which contains fuses for each circuit feeding electric devices, e.g., heaters, grinders, fans, refrigerators, etc. Further, behind this distribution box, we find a main switch/switch fuse unit with cast iron or sheet steel enclosure. This main switch with the fuse in position can also put 'ON' or 'OFF' power supply to the whole house.

The present article on Miniature Circuit Breaker (MCB) explains how developments are taking place in the field of electrical engineering and it shows how one item functionally replaces a few items and brings about a higher ease of operation and control.

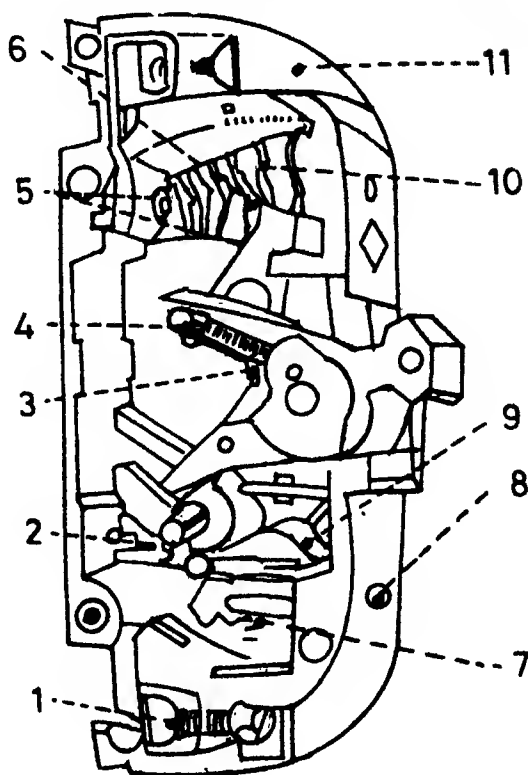
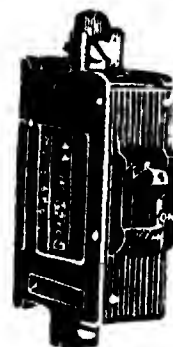
It would be relevant here to discuss something about short circuit and overload protection which are the two important functions of MCB.

Short circuit protection

What does the fuse do? You might have observed that when the insulation of a cable connected to a heater melts and the two conductors touch each other, or the heating element in an electric iron touches the body, the normal current cause sparks and the fuse in the circuit blows off. This type of situation in an electric circuit is called a short circuit which happens when a live wire touches another wire, the ground or the body of an electric appliance. In a three phase supply system, there can be a short circuit between all the three phases. This happens during a high storm and causes total power failure. The fuse gives protection in case of short circuit by melting itself.

Overload protection

In a motor operated electric equipment, like a refrigerator, a grinder, a mixi or an air conditioner, a situation such as too much friction in the bear-



- 1 Universal terminal for front or back entry, with cable-gripping clamp
- 2 Trip lever
- 3 Two member, trip free mechanism
- 4 Twin main springs
- 5 Contacts
- 6 Anti welding contact tips

- 7 Solenoid for short circuit protection
- 8 Insert, for flush mounting
- 9 Bimetallic strip for overload protection
- 10 Arc chamber with de-ionising arc chute
- 11 Terminal shroud

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ing or a similar mechanical jamming in the driven system can cause flow of two normal current a few times, say upto two times. If this is not prevented, the motor would burn out. The device which is fitted in the starter of such a motor driven equipment is called overload protective device, usually known as thermal overload relay.

What is MCB

MCB stands for miniature circuit breaker and has been recently developed. It functions as a manually operating switch. It includes protective elements for overload and short circuit conditions in the event of which the MCB trips.

In a motor starter, short circuit protection is provided by fuses which need to be replaced from time to time. In MCB it is provided by a magnetic relay which can be reset once it trips.

Application and advantages of MCB

(i) It is a highly compact control and protective device for lighting circuits and circuits feeding power to a motor, in a house or a factory;

(ii) In the event of a short circuit, it does not require fuse replacement which is cumbersome. It readily permits identification of a faulty circuit;

(iii) MCB can be used for A.C. as well as D.C. circuits. For A.C. circuits, it is available in single/double/triple pole versions;

(iv) It can be used as an isolating switch for maintenance purpose, which is normally done by switching 'OFF' the main switch in the house or by an Isolator provided in an equipment circuit in a factory. There is also a provision for locking the individual MCB so that no unauthorised person can move the handle from the 'ON' to 'OFF' position and vice versa;

(v) In case of transient faults, they make possible immediate restoration of power supply without the necessity of any replacement; and

(vi) MCBs are ideally suited for protection of motor circuits (i) 240 V single phase and (ii) 415 V, 3 phase either in the house or in the factory.

Rating

The ratings in which the MCBs are

available in the market are given below:

(i) *Current rating* 5/10/15/20/30/40/50/60 Amp.

(ii) *Voltage rating* 240 V single phase or 415 V, 3 phase A.C. and 50 V/110 V.D.C.

The above current and voltage rat-

ings are suitable for: (i) 240V, single phase motor from 0.62 H.P. to 10 H.P., (ii) 415 V, 3 phase motor from 0.5 H.P. to 30 H.P.

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Science Quiz

Tick the correct answer

- $\phi X = 174$ is
 - a synthetic hormone
 - an insecticide
 - a carcinogen
 - a single stranded DNA virus
- Genentech is
 - a recently discovered gene for nitrogen fixation
 - a California based biotechnology company
 - recombinant DNA technique
 - gene data bank
- International Rice Research Institute (IRRI), International Potato Research Centre (CIP) and International Crops Research Institute for Semi-Arid Tropics (ICRISAT) are located respectively at
 - Peru, Manila (Philippines) and Hyderabad (India)
 - Hyderabad, Peru, Manila
 - Manila, Peru, Hyderabad
 - none of the above
- Silver fish is
 - an ornamental fish
 - an insect
 - a sea mammal
 - a bird with silvery feathers
- Quick silver means
 - silver
 - silver oxide
 - mercury
 - none of the above
- Siemen is the unit of
 - conductivity
 - turbidity
 - sedimentation
 - electron spin resonance
- Enology deals with
 - insects
 - wines and wine making
 - scientific languages
- Indian Institute of Astrophysics,

Central JALMA Institute for Leprosy and National Institute of Oceanography are located respectively at

- Panaji, Agra and Kodaikanal
 - Panaji, Kodaikanal and Agra
 - Agra, Panaji and Kodaikanal
 - Kodaikanal, Agra and Panaji
9. In scanning electron microscope images of the specimen are formed as a result of
- reflection of electrons from the specimen
 - transmission of electrons through the specimen
 - diffraction of the electrons from the specimen
 - none of the above

10. The temperature at which Fahrenheit and Centigrade thermometers read the same is
- -40°C
 - 40°C
 - -140°C
 - 140°C

11. Smallest bone in the human body is
- malus
 - incus
 - stapes
 - none of the above

12. Lyophiliser is used in
- gel filtration
 - freeze-drying a material
 - gel separation
 - cutting thin section of specimen

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(Answers on page 555)

Multigrades or multipower relations

SUM of a set of numbers may equal the sum of another set of numbers. Such an equality may be written in the form

$$a+b+c+d+\dots\dots\dots$$

$$=a_1+b_1+c_1+d_1+\dots\dots\dots$$

In some cases this relationship between the sets of numbers may remain true even when each number is raised to the same power, that is,

$$a^n+b^n+c^n+d^n+\dots\dots\dots$$

$$=a_1^n+b_1^n+c_1^n+d_1^n+\dots\dots\dots$$

We may call such relations multigrades or multipower relations. The least multigrade possible is a second order multigrade true for both $n=1$ and 2 . A third order multigrade is true for $n=1, 2$ and 3 ; and so on.

One might think that forming a multigrade is probably a difficult task. However, there is a simple procedure following which the various multigrades may be obtained easily. This procedure is explained below.

Start with a simple equality such as

$$1+4=2+3$$

Now, add K to each term of this equation to form a new equation :

$$(1+K)+(4+K)$$

$$=(2+K)+(3+K)$$

Reversing the sides of the new equation and combining the resulting equation with the key equation leads to

$$1+4+(2+K)+(3+K)$$

$$=2+3+(1+K)+(4+K)$$

All the terms of this equation must be different. To ensure this the value of K must be chosen carefully. Obviously, $K=1$ is not admissible because this makes two terms on the left as well on

the right equal to 4 and 2 respectively. The value $K=2$ likewise makes two terms on the left as well on the right equal to 4 and 3 respectively and is, therefore, to be eliminated. Hence the least value of K which is admissible is 3 which yields

$$1+4+5+6=2+3+4+7$$

Cancelling out the common term 4 from both the sides, we have

$$1+5+6=2+3+7$$

This relationship is also true when each term is raised to the second power, that is

$$1^2+5^2+6^2=2^2+3^2+7^2$$

Thus we have the second order multipower relation which is true for $n=1$ and 2 :

$$1^n+5^n+6^n=2^n+3^n+7^n$$

The third and higher order multigrades may be obtained by repeating the same procedure. Each operation will raise the order of the multigrade by unity. For example, from a second order multigrade one can derive a third order multigrade; from a third order multigrade a fourth order multigrade may be obtained, and so on.

If, in the above multigrade, we add K to each term, reverse the equation so formed and combine it with the original equation we can obtain

$$1^n+5^n+6^n+(2+K)^n+(3+K)^n$$

$$+(7+K)^n$$

$$=2^n+3^n+7^n+(1+K)^n+$$

$$(5+K)^n+(6+K)^n$$

The lowest value of K that makes all the terms different is 5 . This value when used in the above equation yields:

$$1^n+5^n+6^n+7^n+8^n+12^n$$

$$=2^n+3^n+6^n+7^n+10^n+11^n$$

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Cancelling out the common terms we have the following order-three multipower relation :

$$1^n+5^n+8^n+12^n$$

$$=2^n+3^n+10^n+11^n$$

This equation may be seen to be valid for $n=1, 2$ and 3 :

$$1+5+8+12=2+3+10+11$$

$$1^2+5^2+8^2+12^2$$

$$=2^2+3^2+10^2+11^2$$

$$1^3+5^3+8^3+12^3$$

$$=2^3+3^3+10^3+11^3$$

The fourth order multigrade can easily be obtained from the above third order multigrade, for $K=4$. This multigrade valid for $n=1, 2, 3$, and 4 is of the form

$$1^n+6^n+7^n+8^n+14^n+15^n$$

$$=2^n+3^n+9^n+10^n+11^n+16^n$$

The next higher, i.e., fifth order multigrade ($n=1, 2, 3, 4, 5$) as obtained for $K=7$ is

$$1^n+6^n+7^n+17^n+18^n+23^n$$

$$=2^n+3^n+11^n+13^n+21^n+22^n$$

Different multigrades can thus be obtained easily by following the above procedure. However, it may sometimes be fascinating to obtain some unusual multigrades. These multigrades are not easy to form. But attempt will be made here to obtain at least one such multigrade.

We start from the same basic equation, namely, $1+4=2+3$ and form a second order multigrade ($K=4$) of the form

$$1^n+4^n+6^n+7^n$$

$$=2^n+3^n+5^n+8^n$$

Before proceeding further we would like to recollect a very standard result of mathematics The equation,

$$a+b+c+d=e+f+g+h$$

remains still true when the respective terms on the two sides of the equation are combined to form two-digit numbers in the manner shown below :

$$ae+bf+cg+dh$$

$$=ea+fb+gc+hd$$

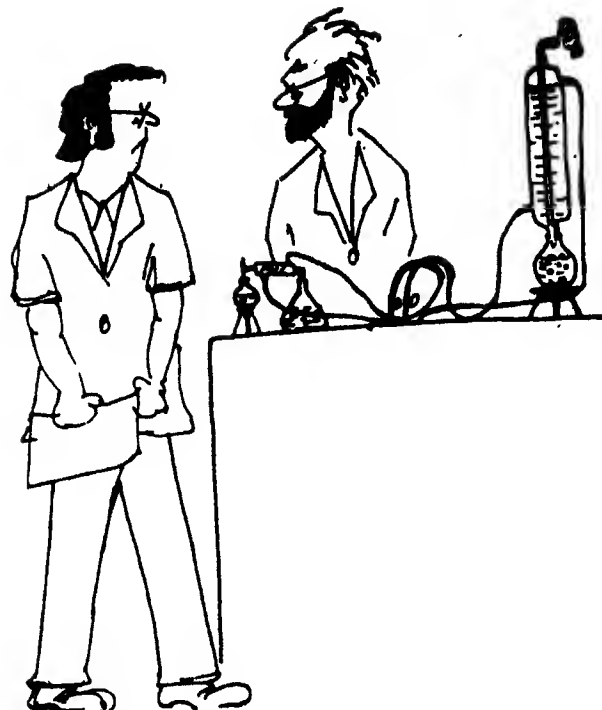
The proof of this is quite elementary. We expand each term

(Continued on page 563)

354 MISSING
INMATES
OF AN ASYLUM
RETURN



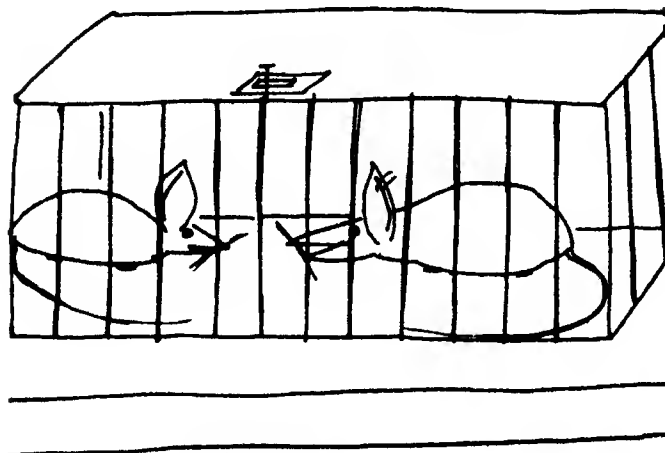
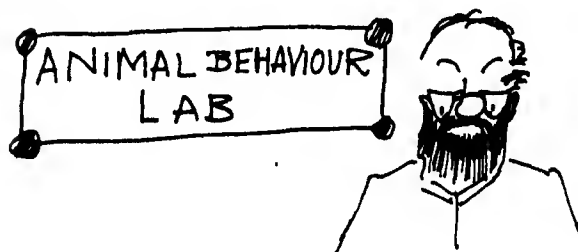
"They might have found the assylum a lot more saner place"



"So they told you that suicide rate in our institution is high. Well, young man look at it this way—in these days of inflation and unemployment, this is a place that shows the sure short cut to heaven"



"This is not a garbage dump. These are empty cartons, refill packs, top flaps, bottle caps, wrappers etc., etc., for the 'Contests' my husband takes part in"



"No problems here; I have trained that chap very well. Whenever I press the fifth rod, he gives me food"



FOR HER

Can you select your child's sex?

THE necessity and hence the desire, if not the demand, for producing children of desired sex is on the increase because of the increasing world-wide acceptance of one or two children family norm.

It is well-known now that sex of a child is determined right at the moment of fertilisation by the particular type of sperm—whether X bearing (will lead to formation of female fetus) or Y bearing (will lead to formation of male fetus) contained in the husband's discharged semen (which, as we know, contains an equal proportion of both the varieties) which happens to penetrate the ovum.

Now how can one arrange to produce a child of desired sex? Review of literature reveals that only two techniques have so far been tried. They are—as they have been rightly named—separation technique and facilitation technique.

Separation technique

As the name indicates, in this technique an attempt is made to separate from husband's semen the two types of sperms (X and Y) by some artificial means in the laboratory, and then the wife is artificially inseminated with the separated, desired type of sperm of her husband.

The various methods of separation that have been used are—spontane-

ous settling or sedimentation, forced settling or centrifugation, electrophoresis, and albumin layering. The last method has been found to be the best—giving 80% separation. Since this is the best method developed so far, a brief description of the method is relevant. The method is quite simple. A vertical column of bovine albumin of increasing density is prepared. The semen is added to the top of the column. It is observed that the Y sperms show a distinct tendency of swimming and diffusing downwards into the densest (20% albumin) zone. The Y sperms may then be recovered from this zone and used for artificial insemination to produce male babies. The sperms left behind in thinner zone will then naturally contain predominantly X sperms (as reported by R.J. Levin of University of Sheffield, U.K. in the *IFFP Medical Bulletin* of February 1982).

Now, what are the bases of the separation techniques? There are two. Firstly, the X sperms are 4% larger than Y sperms, for the former has 4% more DNA than the latter and, secondly, they differ somewhat in their surface charge.

However, there are certain serious drawbacks of separation techniques which make them impractical and untrustworthy, the main drawbacks being a too poor degree of separation (where even 1% impurity can cause failure), a too poor rate of conception from the separated material, a too laboratory (for separation) and doctor (for insemination) dependent and, due to the last reason, not too suitable for mass application. Most important of all, there always remains with these techniques the discomfort of producing a congenitally malformed baby because of abnormal handling of sperms.

Facilitation technique

This technique facilitates the capacity of the desired type of sperm over that of the undesired type after it has been deposited in the vagina by natural intercourse and while they are actually in the female genital tract, by altering the character of secretions of the latter.

Various facilitation techniques that have been tried can be classified as follows:

- (i) Planned intercourse; and
- (ii) Adoption of active artificial measures; (A) Applied locally or directly or (B) Systemically or indirectly.

Planned intercourse

The advantage here is that it can be practised by a man and a woman in their bed room privacy without any medical help, implements, drugs or chemicals. It has been found that a sexual intercourse performed before or on the day of ovulation (specially before) as indicated by the change or shift (a transient drop followed by sustained rise by half a degree) in her morning waking temperature (if she has been keeping a record of it) or as calculated from her usual menstrual cycle (by the formula that ovulation occurs 14 days before the expected day of next menstruation) leads to conception of more male babies. While this is an observed fact—although nowhere near 100%, true the reason for the incidence is not known. The suggestions are—the younger the ovum the more likely it is to be fertilized by a Y carrying sperm, and, that the Y sperms perhaps survive more effectively in the female genital tract in that phase of the reproductive cycle, perhaps due to a less acidic vaginal pH and a more alkaline cervical mucous. Besides, it has also been found by some researchers that the more is the frequency of coitus the higher is the incidence of birth of male fetuses. It is believed to be due to the increased possibility of insemination (due to frequency) on those days which are associated with conception of more male fetuses as mentioned above. The additional support towards the above observation is the report that a man with more than one wife tends to have more female babies with each of his wife. While there is statistical evidence to support these observations, scientific explanation for them is still not available.

Back in 1970, L.B. Shettles of United Kingdom reported in *International Journal of Gynaecology and Obstetrics* (Vol. 8, Pp. 643-647), a

FOR HER

few other techniques of intercourse for facilitation—like deep vaginal penetration, entry from the back and stimulation of female orgasm for boy babies (for Y sperm facilitation) and shallow penetration, face-to-face coitus and avoidance of female orgasm for girl babies (for X sperm facilitation).

Since the factor, female orgasm, has been emphasised so strongly it needs further discussion. According to the above suggestion, it would appear that more sexy (i.e., sexually hyper-sensitive) the woman is, the more likely she is to conceive boy babies because she is more likely to have orgasm. Sperm enhancement function of orgasm has been explained by Shettles by suggesting that orgasm leads to liberation of excess of fluids from vaginal walls into vagina (vaginal transudate) which neutralise vaginal acid and thus facilitate Y sperms. However, the theory has been opposed on the ground that orgasm is actually associated with partial or complete dissipation of vaginal vaso congestion—the necessary prerequisite for formation of the fluid. Besides, on trial, Shettelle technique has proved to be of questionable effectiveness.

Direct techniques of sperm facilitation

The direct technique involves direct alternation of local intragenital condition of the female by some medicine or chemical applied directly locally which would facilitate the desired type of sperm. The method that has gained the maximum popularity is alkaline douching of vagina. There are reports that washing the vagina with alkaline solution (e.g., 2% sodium bicarbonate) leads to a higher incidence of conception of male babies indicating Y sperm facilitation by this chemical. But, now the method had been proved to have no real scientific basis on the following grounds: firstly, it has been found that both X and Y sperms survive equally well in both acid and alkaline buffers *in vitro*; secondly, motility of Y sperms has not been found to be differentially influenced by environmental pH; and thirdly, even pre-treating sperms with bicarbonate has not been found to change sex ratio of the babies produced (reported by R.J. Levin of Uni-

versity of Sheffield in 1982, as referred already).

Indirect or systemic technique of sperm facilitation

This technique induces change in the whole body system of the intending female which, hopefully, in turn, would alter the environment of the genital tract. Experiments have been done on this method mainly by altering the diet of the woman. One such technique suggests that for conceiving boy babies diet of the woman should be artificially enriched with sodium, and calcium and magnesium contents should be reduced. The opposite diet should be adopted for conceiving girl babies. It is recommended that such diet should be taken for 4-6 weeks before the planned intercourse for having the baby of desired sex. However, researchers of this technique warn that such diets being grossly unbalanced

can be very dangerous and hence should be given only to very healthy persons under strict medical supervision for a maximum period of 4-6 weeks at a time. The method aims to alter the ionic environment of the female genital tract (i.e., the ionic concentrations of vaginal, cervical, endometrial and tubal fluids) and thus facilitate (or antagonise) sperm of the desired type. Obviously the method is too complicated and is in its infancy for any firm comment.

So, summarily, what then is the present position regarding human sex pre-selection? Unfortunately, it is one of uncertainty, hypothesis and impracticability leaving a great arena for further research in this direction.

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Hay box — fuel saving cooking device

INDIA is predominantly an agricultural country. Eighty per cent of the population is rural; rural population in general has limited needs. There life is simple and standard of living is low.

Rural housewives, besides their domestic work such as cooking, serving, and rearing children, have to work at farms along with their men-folk. The rural housewife is hard pressed for time.

Cooking is one of the essential routine jobs on which a housewife spends quite a long time and pays more attention. Now, domestic fuel problem is becoming serious, particularly in rural areas. Rural women use either cowdung or firewood for cooking. Cowdung is now being more frequently and popularly used as manure rather than as fuel. It is also utilized in go-bar gas plants. Cutting of forests for firewood is strictly prohibited by Government. Further, firewood is becoming scarcer and more expensive. Cooking on firewood

takes longer and requires more attention to prevent food from being overcooked.

The newer devices such as kerosene stoves, hot plates, and gas are common in urban areas. Though cooking is quicker on these newer devices, the initial expenditure on them is high and, then, kerosene scarcity is increasing day-by-day. Hence, rural or low income class of urban population cannot afford such devices. It is therefore necessary to think of a device which consumes less fuel, is less expensive and convenient to use.

One such fuel saving equipment suited for cooking is 'hay box'.

Hay box is a wooden box in which paddy hay is packed to three-fourth of the height, with a depression left for the cooking pan (Fig.1). It has a pillow filled with the paddy hay, to fill the rest of the box. The food to be cooked is boiled for a certain period on the regular cooking fuel and, when half done, the pan with tight lid is

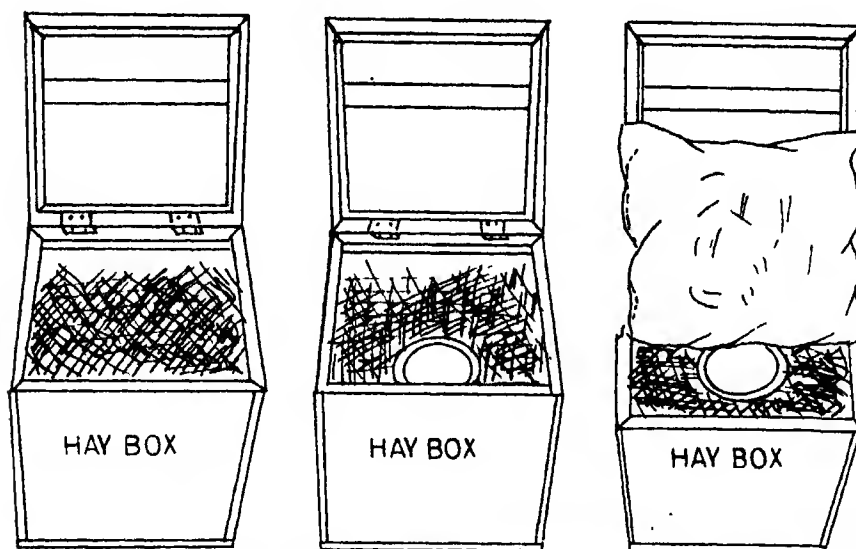


Fig. 1. (Left) Box containing paddy hay with a depression for the cooking pan; (Middle) Box containing cooking pan with a tight lid; (Right) Pillow filled with the same insulating material to cover the rest of the box

transferred to the box. Then the box is closed. The heat which is retained due to the insulating material around completes cooking of the food.

When a housewife uses 'hay box' she saves fuel, because the partially cooked food gets cooked completely in it. She saves time, as she does not have to pay attention to the food when it is being cooked in hay box. She gets hot food ready to eat when she returns home after her work outside. The food remains hot in the hay box for nearly three to four hours.

Silk cotton, coconut fibre, wheat hay and paddy husk can also be used as filling materials instead of paddy hay. They are easily available every-

where. Silk cotton has the best heat retention capacity. The next efficient materials are coconut fibre and wheat hay. Paddy hay is the least efficient one.

One cup of rice takes at least 15 minutes to get cooked completely on hot plate. Whereas rice needs only 2-3 minutes of boiling on hot plate before placing it in different insulated boxes for complete cooking. Heat which is retained by the insulating material completes cooking of food in half-an-hour. Actually, fuel worth 12-13 minutes of burning is saved. Hay box can also be used for cooking pulses and vegetables. Potato takes half-an-hour to get cooked completely on hot plate whereas, in any of the insulating

materials, it needs only 5 minutes of boiling on hot plate. Afterwards it can be transferred to any one of these boxes to be cooked completely within half-an-hour without further application of heat. Twentyfive minutes of fuel is saved. Hay box not only saves time, energy and fuel, but also saves vitamins from destruction in cooking. Longer periods of cooking at a high temperature and exposure to light destroy some of the B-complex vitamins sensitive to heat and light. Foods cooked in hay box are exposed to a high heat for a short period. So there is 60%-70% retention of vitamins (thiamine and riboflavin). Hay box cannot be used for frying and roasting. Here food will not be ready for consumption soon. However it has its own merits—

1. Even an old wood box for preparing hay box can be used.
2. Different filling materials like silk cotton, coconut fibre, wheat hay, paddy hay and paddy husk, whichever is available easily, can be used as an insulating material.
3. Housewives save fuel and time.

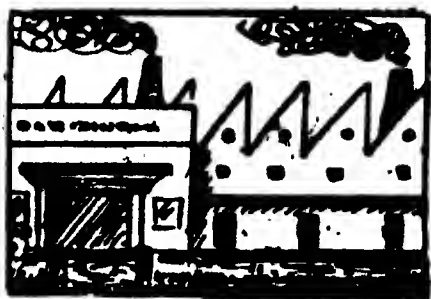
NIRMALA A. HADIMANI

LEELA PHADNIS

College of Rural Home Sciences
Dharwar (Karnataka)

Answers to science quiz:

1. (d). 2. (b). 3. (c). 4. (b). 5. (c). 6. (a).
7. (b). 8. (d). 9. (a). 10. (a). 11. (c).
12. (b).



SCIENCE IN INDUSTRY

Technique for tenderization of chilled meat

THE Central Food Technological Research Institute, Mysore, has developed a conditioning technique which not only improves quality, tenderness, juiciness and flavour of meat, but also reduces cooking time. It also checks the mutton from maturing. The mutton of an old sheep remains as tender as the mutton of lambs.

In this technique, the carcass is held at a temperature of 15°C-20°C for 6 hr-8 hr, and then chilled at 0°C-2°C for 16 hr-18 hr by hanging in a special posture by the pelvis or vent, and not by the Achilles tendon or ankles which is the usual practice. The entire procedure takes 24 hr.

The technique will be beneficial to the food service trade, modern meat stalls in metropolitan cities, and exporters who have to resort to storing of meat under chilling or freezing conditions.

New infant food

THE Central Food Technological Research Institute, Mysore, has

developed a new spray-dried milk food for infants, which is expected to enter the market soon.

Unlike other commercial formulae which contain about 22% protein, the protein content of the new infant food is only 2%; it also has an adequate level of essential fatty acids which can be easily digested by babies. The level of protein and essential fatty acid of the product, when reconstituted with water, is similar to that of breast milk.

The new infant food has undergone successful feeding trials in a local hospital. The preparation of this product requires less milk than that required by other commercial products.

Double effect evaporator

THE Central Food Technological Research Institute (CFTRI), Mysore, has designed a double effect evaporator for use in a tomato concentration plant being set up by the Bihar Fruit and Vegetable Development Corporation at Patna. The plant can process 50 tonnes of tomato to produce 7½ tonnes of highly concentrated tomato paste per day. A notable feature of the CFTRI design is that it effects reduction in energy consumption by about 40%.

CFTRI is also assisting the Bihar Fruit and Vegetable Development Corporation in setting up a fruit processing plant capable of processing 50 tonnes of tomato, or 20 tonnes of mango, or 10 tonnes of pineapples, or 5 tonnes of litchi in one day.

Micromanometer

THE National Aeronautical Laboratory, Bangalore, has developed a micromanometer which has several design features that enhance its

accuracy and operational convenience. It is a null reading instrument with a movable reservoir whose height is measured by a height gauge with a digital readout (range, 300 mm; least count, 0.01 mm of silicone fluid). The drift of zero arising from changes in ambient temperature is almost eliminated by compensating for the effects of changes in surface tension and thermal expansion. The instrument has a quick response.

The know-how for this instrument can be had on non-exclusive basis from National Research Development Corporation of India by paying a lump sum premium of Rs. 15,000.

Glass-reinforced gypsum

WOOD, a natural composite material made of cellulosic fibre embedded in a matrix of lignin, is one of the primary construction materials for house building. The ever-increasing volume of construction work demanding more and more natural wood has caused not only gradual depletion of its source, i.e., forest, but has also led to its ever-soaring prices and has created ecological imbalance.

The Central Glass and Ceramic Research Institute, Calcutta, has developed a glass-reinforced gypsum (GRG), using glass fibre and high strength plaster of Paris; the latter ingredient has also been developed at the institute. This composite material has a great potential for replacing wood in the construction of doors, partition walls, etc. Unlike wood, it is a random fibre composite and has adequate strength both in longitudinal and transverse directions. Besides eliminating fire hazard, it is free from the inherent disadvantages associated with wood, viz., rotting and warping. Doors of GRG result in a cost saving of 25%-50% over those of wooden doors.

ENVIRONMENT

Is rain water sterile?

It is commonly believed that rainwater is the purest form of water, but it is not true. Anything in the air, including auto exhaust gases, industrial emissions, dust particles and other forms of gaseous pollutants, can get into rain water. Microbes in rainwater are not an exception.

Biologically, atmospheric air contains mixtures of suspensions of protozoa, bacteria, spores of cryptogams and pollen of flowering plants which are found suspended as microbial clouds in the atmosphere (Fig.1). During rain, the rain drops pick up air-borne microbes making rainwater non-sterile.

Microorganisms commonly occur in atmospheric dust. Water that falls as rain, hail, or snow whether on land, over ocean or on the poles may contain a surprisingly large microbial population. Many more bacteria are found in the raindrops at the beginning of a shower than after a long rainy spell. Raindrops in cities contain more microbes than rain falling on upland forests or pastures. Rain falling on large cities may wash down annually more than 5 million organisms to each square meter. Such an estimate is based on the knowledge that rain contains from 1-25 micro organisms per ml.

Rain can originate at various heights in the atmosphere and the microbial cloud which is below rain may be cleared by falling water drops, while the microbes above it remain undepleted.

In water falling as snow, the numbers are usually larger than those in raindrops, presumably because of the larger surface area of the snow particles. As many as 500 microbes per gram of snow and 20,000 per gram of hail have been recorded. Snow in the high mountains and the water from glaciers are practically sterile.

Natural raindrops vary in size up to a maximum diameter of about $5\text{ }\mu\text{m}$ ($1\text{ }\mu\text{m} = 10^{-6}\text{m}$). Above which they become unstable and break up during fall into smaller droplets (Fig.2). A water drop falls at a terminal velocity (ranging from $1\text{ }\mu\text{m/sec}$ to $10\text{ }\mu\text{m/sec}$) greater than the microbial particle in its path. Calculations suggest that raindrops of more than $2\text{ }\mu\text{m}$ in size

have the greatest efficiency in picking up particles. It is reported that the collection efficiency of spores of $4\text{ }\mu\text{m}$ in diameter is about 25%, while of $20\text{ }\mu\text{m}$ - $30\text{ }\mu\text{m}$ spore size is 80%-90%. Hydrophilic particles are more easily picked up. Nothing is known about the pickup of non-spherical spores.

Raindrops can act as electrostatic collectors because of two effects. The coulombic attraction between oppositely charged spores and raindrops and by induced attraction (Fig.3).

The phenomenon appears to be fundamentally distinct from the characteristic of +ve and -ve charges acquired by particles in colloidal solution. The manner in which they are captured and carried by raindrops is influenced by the wettability of the



Fig. 1. A microbial cloud in the atmosphere

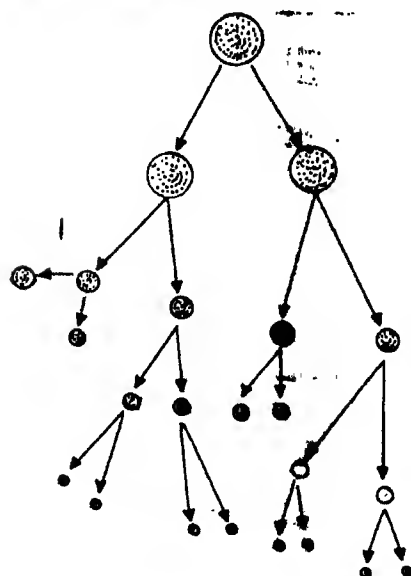


Fig. 2. Raindrops breaking to form droplets.

microbial spore surface. The spores are always observed at the boundary layer where the droplets are present. The readily wettable spores of the fungi like *Cephalosporium*, *Fusarium*, *Verticillium* and *Puccinia* enter droplets with ease and are carried within. At low velocity the non-wettable spores of *Aspergillus*, *Cladosporium*, etc., are captured by molecular adhesion to the surface of droplets. A two-year study of the microbes in rain water at Mysore has revealed the dominance of 'Aspergilli' type spores over others in precipitated water. However, non-wettable spores are minute in size (3 μ m-8 μ m) and are not deposited by sedimentation or impaction. They are carried into upper air where they may form a biotic zone.

After a shower, as water sinks some non-wettable spores are deposited on the moist soil surface or debris, where they germinate, sporulate and disperse as dry spores by wind in a short time, contributing to air-borne microbial clouds in atmosphere after rainy days.

Role in disease spread

Microbes in rain water have great influence on the terrestrial phase of ecosystem. They cause several processes of plant infection or the infection in the respiratory tract of

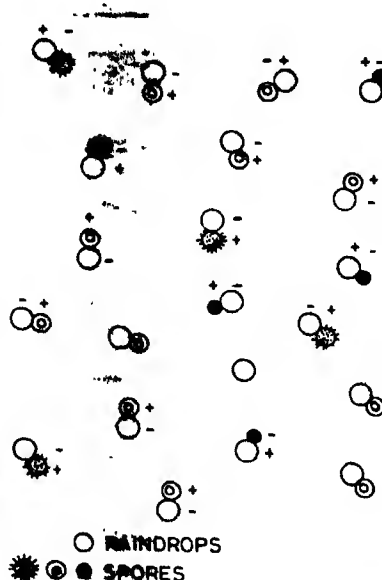


Fig. 3. Attraction between oppositely charged spores and droplets

vertebrates. Dissemination of wheat rusts due to rains from the Himalayas to the northern plains and from Nilgiris and Pulni hills from south to central India is well-known. Recent studies on the epidemiology of brown and black rusts have shown that quite often spores from southern sources are directly transported to central India and deposited mainly by rains. Such a spread occurs to a distance of more than 600 km, sometimes without infecting the fields. Micro-organisms in rain also play some role in spread of animal diseases especially the foot and mouth disease of cattle and sheep.

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The omnipresent polluted air

THE earth is the only object known at present in the entire universe capable of supporting life. This life supporting property of our planet is due to its unique atmosphere. There is now a growing concern about the pollution of the atmospheric air by man made activities. For our better living we need better food, better clothing, etc. Also we need unpolluted atmosphere. Before we talk more about polluted air we shall define what clean air is. The clean air is defined as the air occurring in areas sufficiently distant from places of human activities and other abnormal influences. Pollution of the air is generally associated with man's industrial and domestic activities. Though many of the gaseous pollutants are also emitted by nature (such as volcanic eruptions) man's activities do adversely affect the quality of the atmospheric air particularly near dense urban areas and near large emission sources.

Air pollution caused by human activity has always existed ever since fire came to be used, but the present state is so bad that we have to control it.

Carbon monoxide (CO) is pro-

duced mainly by the incomplete combustion of carbon and its compounds. The automobile is by far the largest single emission source of this gas. It is more toxic than other pollutant gases. It reacts with hemoglobin in the blood forming a stable compound which restricts transport of oxygen from lungs to cells. A relatively low concentration of CO, because of its high affinity to hemoglobin, is able to displace a considerable amount of oxygen to form the CO-hemoglobin complex known as carboxyhemoglobin. Oxygen transport problem in humans can arise when the carboxy-hemoglobin content of their blood reaches 5%. It is to be noted here that smoking a packet of cigarettes a day produces carboxy-hemoglobin levels of about 5%.

Oxides of sulphur (such as SO₂, H₂S and compounds of SO₄) also add to the pollution of air. These gases are emitted by combustion of fossil fuels (coal, oil, natural gas, etc.) containing sulphur (thermal power plants), smelting of sulphite ore and from biological processes. These gases are washed down from the atmosphere in the form of sulphuric acid (H₂SO₄). The presence of increasing concen-

trations of H_2SO_4 in the lower atmosphere is indicated by the increasing and more widespread occurrence of "acid rain".

Oxides of nitrogen (N_2O , NO , NO_2) also produce "acid rain". These gases are produced from the biological activities in the soil, in furnace and also from the automobile engines. These gases through many photochemical chain reactions, produce gases which are irritating in odour and corrosive. In the atmosphere these gases produce nitric acid (HNO_3) which is washed down and contribute to "acid rain".

Acid rain, is nothing but rainfall with a higher amount of acidity. The acidity of a aqueous solution is defined by pH, a way of indicating hydrogen ion concentration. Pure distilled water is neutral and has a pH value of 7.0. The pH value of the natural rainfall is 5.7 since it is in equilibrium with atmospheric CO_2 and is therefore slightly acidic. The pH value of a tomato juice is 4.3 and that of lemon juice 2.2. Most of the fish species will die in a water with a pH of 4.4.

Typical pH values of rainfall over much of eastern North American are in the range of 4.0-4.5. According to the published data of WMO sponsored pH monitoring programme in our country during 1977 to 1979, the rainfall pH values lie mostly in the range of 5.5 to 6.9 over Bangalore, Delhi, Hyderabad, Nagpur and Pune. However, Pune shows a decreasing trend in pH value with a minimum of 4.93 in 1979. As defined earlier acidity of the rain water increases when the amount of oxides of sulphur and oxides of nitrogen increases in the atmosphere to produce more H_2SO_4 and HNO_3 . In this context, it is feared that the Taj Mahal will be affected by the pollutants emanating from the Mathura Oil Refinery and local industries. Acid rain also reduces fertility of the soil.

Carbon dioxide (CO_2) which is produced world-wide by the combustion of fossil fuel has become a topic of concern as it is increasing at a rate of about 7% per year. Its increase in concentration will increase the surface temperature of the earth as it absorbs infrared radiation emitted by the

earth. According to a theoretical estimate, doubling of the CO_2 content will increase the earth's surface temperature by $3^\circ C$ ($\pm 1.5^\circ$). This will cause serious climatological changes.

The ozone layer in the atmosphere is important to our life since it absorbs potentially harmful solar ultraviolet radiation. A small decrease in the amount of ozone will increase the amount of this radiation reaching the earth's surface thereby increasing the incidence of skin cancer. Presently, there are many man made pollutants which are capable of depleting ozone amount. These include oxides of nitrogen released from nitrogen fertilizers, supersonic transport exhausts and from nuclear explosions.

So, there are many gases which pollute our atmosphere. A systematic study, which is lacking at present, is needed to monitor and regulate these emissions.

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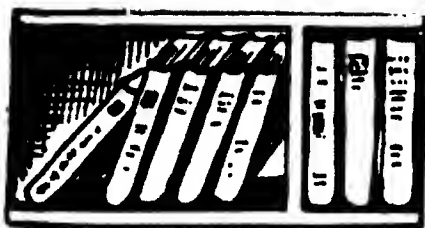
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BOOK REVIEWS

DICTIONARY OF ORGANOMETALLIC COMPOUNDS, Chapman and Hall, London (1984), 3 Volumes, approx. 3000 pages (Available with B. I. Publications, 54 Janpath, New Delhi 110001), £575 (for 3 Vols)

FROM the publishers of the well-known and standard reference work Heilbron's *Dictionary of Organic Compounds* (now in 5th edition) comes *Dictionary of Organometallic Compounds* in three volumes. This is the first major dictionary-type publication in organometallic chemistry, which since 1950s has registered phenomenal progress. The publication of the *Dictionary* marks, in fact, the belated recognition of organometallic chemistry as a discipline in its own right. The listing of as many as 15,000 organometallic compounds only testifies to the fact that this branch of chemistry is now a full-fledged discipline. The importance of organometallics derives from the fact that they find use, among others, as catalysts in a wide range of chemical, biological and industrial processes.

The *Dictionary of Organometallic Compounds* (DOC) is, however, to be viewed as complementary or a companion to both Heilbron's *Dictionary* and Pergamon's treatise *Comprehensive Organometallic Chemistry* (Barton and Ollis; 9 Vols, 1982). DOC covers twice as many compounds as Pergamon's *Dictionary* and 15 times as many as Heilbron's. The advantages of DOC for the busy scientist lie in the encyclopaedic structure of the compilation which pinpoints data on compounds unlike Pergamon's. However, when electronic publishing, especially in relation to databases (which need to be continually updated), is fast replacing conventional hard copies, the latter's use predictably will be limited to Third-World researchers

because of their inaccessibility to electronic media. A case in point is the monumental *Beilstein Handbook of Organic Chemistry* which will become "Beilstein Online" from 1987—database being located at Rachinformatiionszentrum in Karlsruhe (FRG) where Chemical Abstracts Service (CAS) will also have its copy.

The data provided in each entry in DOC include: molecular formula, structure diagram, preferred names and important systems, CAS registry number, physico-chemical characteristics, reactions, uses as well as toxicity data, besides selected literature references.

The *Dictionary* is divided into element sections, and within each section the entries are arranged in order of molecular formula according to Hill convention (C, H, other elements in alphabetical sequence of element symbol). Where no carbon is present the elements including H are arranged alphabetically. There is a section for every element except for H, C, N, O, P, Se and Te, the halogens, the noble gases, and unstable radioactive elements for which no organometallic compounds have been well characterised.

Every entry is numbered, the entry consisting of the metal element symbol followed by a 5-digit number.

While the first two volumes consist of main entries (Ag-Fe and Ga-Zr), the third volume comprises three indexes: compound names, molecular formulae and CAS registry numbers. Annual supplements to the *Dictionary* will also be issued, the first supplement being scheduled for release in September 1985.

The *Dictionary* will be an invaluable tool to specialists in organometallic research whether they are basic researchers in organic chemistry and biochemistry or technologists working in industry as well as to post-graduates working in analytical or pharmaceutical laboratories.

Discounts of 15% and 20% (this rate to customers providing names and addresses of end users) are offered by the Indian distributors.

P.S. SHANKAR

THE UNIVERSE WITHIN By Morton Hunt, Corgi Books (Available with:—

India Book Distributors, 107/108, Arcadia, Nariman Point, Bombay-400021), pp.400, £ 2.95

EVERY now and then, one hears some political leader in the country exhorting scientists to inculcate among the masses scientific temper, an attitude to think and work in a logical and systematic manner. It is firmly believed that scientific temper can be inculcated among the masses by popularising science and technology through various mass media. After reading the book under review, one begins to wonder whether all these intellectuals really know anything about scientific temper or the basic purposes of science popularisation. There seems to be an abysmal lack of understanding of the human mind itself among our intellectuals, not to speak of the masses at large. The basic purpose of the book under review is to fill the void in their understanding of the human mind.

Humans are basically illogical beings. They behave in logical and systematic manner only in a particular set of circumstances or when they themselves want to do so. Experiments have shown that a man acquires scientific temper, that is he behaves in a logical and systematic manner when he undergoes schooling where the rules of logic are taught. In other words if our leaders really want that the masses should have scientific temper, schooling should be made compulsory for every person. This is just one illuminating point the book under review tells about the human mind. In fact, as one goes through this lucidly written book, one finds his beliefs about human mind crumbling one after another. At the same time, he also recognises several things observed about it in his daily life to which he has not given much thought. The book is a marvellous effort at popularising the latest developments in the newly developed field known as cognitive science.

Cognitive science as a discipline came into being more than 20 years ago, when a large number of other disciplines as diverse as computer science, linguistics, formal logic, anthropology, neurology, and child

development began to converge on central issue of human thinking process. Although today it is a recognised science with giants such as Jean Piaget, Noam Chomsky, etc., contributing some revolutionary ideas to the subjects, it has still to produce a single grand unifying theory which explains every aspect of human thinking. At present, it is found to throw light on various specific issues into the subject, namely, memory, problem-solving, etc., each with its own separate laws and theories, which are, of course, not incompatible with one another! The book under review written by a science populariser who has been writing on psychology for a long time, therefore, gives at one place all the latest ideas, experiments and laws not found elsewhere in the literature and which a layman should know. How the mind works, how it creates new ideas and theories, and what makes it superior to a computer, etc., have been discussed in an interesting and entertaining manner.

The book is necessary for one who wants to know how he thinks what he thinks.

DILIP M. SALVI

PHYSICS (PART I & II) By U.S. Kushwaha, Punjab School Education Board, Sahibzada Ajit Singh Nagar-160055, Pp.379 & 283, Rs. 12.80 & Rs.9.75.

THE book under review comprising two parts has been written specifically to meet the requirements of the students of class XI of the Higher Secondary Schools of Punjab. The topics covered in Part I of the text include mechanics, heat and sound while Part II deals with the topics optics, electrostatics, electricity, magnetism and atomic structure. The text has been presented in a lucid and easy-to-follow style with common examples drawn from day-to-day life which makes it all the more interesting. The various physical concepts and principles are introduced in a manner which the students will find no difficulty in following. The mathematics used in the book is simple. To have a better grasp and understanding of various topics covered in the text,

adequate number of questions and problems have been included at the end of each chapter. Moreover, some solved examples are also provided.

The book is expected to be useful for class XI students of Delhi and other Education Boards as well. However, there are many printing errors particularly in Part II of the text. The reviewer finds a seven-page errata that is included at the end of Part II of the book. One only wishes that instead of giving an exhaustive list of errors the author should have made a little effort in the beginning stage to minimise the printing errors. The quality of the paper and the printing are also far from satisfactory. Some improvement in this regard is necessary.

P.K. MUKHERJEE

CURRENT CONCEPTS ON FUNGAL DISEASES OF RICE By S. Gangopadhyay (1983), *Today and Tomorrow Printers & Publishers*, 24-B/5, Desh Bandhu Gupta Road, Karol Bagh, New Delhi-110005, Pp. 349, Rs 195.00 (US \$ 39.00)

INTENSIFIED cultivation of high yielding varieties of rice and undue application of heavy nitrogenous and other fertilizers in recent years have considerably weakened the genetic potentiality of the host cells to resist the fungal pathogens. Rice varieties combining high yielding and disease resistance qualities are yet to be developed.

The book under review deals with the current concepts on the incidence and control of various diseases and postharvest problems. The book contains eleven chapters describing various fungal diseases of rice, viz., blast, sheath blight, brown spot, stem rot, sheath rot, false smut, kernel bunt, fusariosis and mycotoxins in rice. Each chapter describes in detail the symptoms, assessment of loss, epiphytism, pathogen, genetic basis of resistance, scoring system and possible control measures. Since the fusarium disease of rice is caused by different causal organisms the author has coined the new terminology *Fusariosis*, covering various symptoms under various agro-climatic conditions

(Chapter 6). Chapters 7 to 9 deal in detail with the diseases of secondary importance, false smut and kernel bunt as these diseases appear in almost all rice growing areas. "Fungi on and in rice seeds" (Chapter 10) gives a clear picture of the seed-borne diseases of rice and their control measures, including quarantine regulations. The last chapter on mycotoxins in rice is an important and interesting feature, which has not so far received attention. A bibliography covering about 1000 references has been given at the end.

In spite of some printing errors, inexplicit illustrations and the high price of the book, it should find a place on the bookshelves of students, teachers and researchers.

TAPAN MUKERJEE

THE BOTANICAL WORLD By David K. Northington and J.R. Goodin, *Times Mirror, Mosby College Publishing*, St. Louis, Toronto, Santa Clara (1984), Pp.646, \$27.95

THIS book looks like many others which tell us about all the aspects of plant life, be it morphology, physiology of the various ecological habits. However, it stands out from the rest, as in addition to being informative it succeeds in giving us an appreciation of the plant world.

I for one do certainly believe that unless we appreciate the bounty and beauty of Nature, unless we revere life, we cannot work towards its preservation. It is a sheer delight to go through the book. Classically, the study of botany was narrow and compartmentalized. Botanists would invariably lose sight of the whole in their efforts at understanding the parts. The approach of the authors in this book is in keeping with the spirit of the times.

A plant's role is not merely to give us humans food, clothing and shelter but plants are of crucial importance in our ecosystem. In oxygen production, erosion control and in maintaining the overall ecological balance on our planet plants play a major role.

The first chapter is entitled, "Why Botany". Obviously, the authors in-

BOOK REVIEWS

form the readers about the importance of the subject.

Professors K. Northington and J.R. Goodin have written this book after an experience of thirty years of teaching. As they have said in the Preface, "We have found that the texts fail to project the excitement and importance of botany in daily life." They have succeeded in their mission. The book does manage to develop in us an appreciation of the plant world. A longish chapter on wood reminds us of the many experiences we have had during our holidays or field trips to the wilderness. Also, many technical details have been included along with photographs to give the reader information about the various cuts and grains of wood.

Trees can engulf rocks, nails and even trunks of other trees. A photograph shows how an oak tree has cannibalised a smaller Douglas fir tree. Information of this kind certainly makes the study of the subject more exciting.

As mentioned earlier, this is a textbook—It includes exhaustive and comprehensive chapters on all aspects of botany—for example, Origin of Life and Evolution, Agriculture, Energy flows, Forest Management. Up to date with information on Biochemistry and Physiology, the book would be apt for B.Sc.(Hons.) and M.Sc. students. A good addition to any library. And very fascinating for those who are out of touch with the subject after having studied it in school or college. It is a text-book but with a difference!

The last chapter, 'Now, Why Botany?' is a passionate plea to our conscience; It convinces us about the importance of conservation without moralising. The chapter begins with a quotation from "A sand country Almanac with other essays on conservation from round river." by Aldo Leopold.

"He who hopes for spring with upturned eye never sees so small a thing a *Draba*. He who despairs of spring with downcast eye steps on it, unknowing. He who searches for spring with his knees in the mud finds it, in abundance". *Draba* is indeed a small, plain unimportant flower. Botany books give it two or three lines, but never a plate or portrait. But, as Aldo Leopold feels, *Draba's* place

In the botanical world is as important as larger, more visible and more useful plants. He goes on to say, "That realization sets apart the botanically educated from the average citizen. When more of the world's people view themselves as natural members of the biotic community instead of users of it, then the future balance and stability of the community is secure, as is the future of each of its individual components."

RATNABALI MITRA

GEMINI GOD By Garry Kilworth, Penguin Books Ltd., 536 Kings Road, London SW 10 0UH, (Available with: *Penguin Overseas Ltd.*, 706, Eros Apt, 56, Nehru Place, New Delhi 110019), Pp. 240, £ 1.75.

THERE seems to be a definite trend these days among Science Fiction writers to dabble in metaphysical themes. In Greek mythology, Castor and Pollux were twin brothers of Helen of Troy. They became great heroes after they rescued Helen of Troy by invading the City States of Athens. Sailors in storms prayed to them; they became the patrons of travellers and of hospitality as well as of public games. As one myth goes, Zeus set them among the stars after their lives on earth and the constellation of Gemini (i.e., of twin Stars) has since been named after them. Here too, a pair of twins (who happen to be girls this time) who have been looked up to with awe and respect, gain immortality by becoming stars in the Universe. Only, here they get transformed into energy rather than die a natural death.

Gemini God is about a set of experiments which are being conducted on planet Earth, with several sets of twins to study a phenomenon called telemetry. Twins have for long been known to communicate to each other in an unaccountable way. Separated at birth, there have been those who knew the instant their brother or sister died.

As John Strecker, the Project Leader explained, "telepathy involves point to point communication with a physical path in between—Mind Wave. Waves have to travel and travel involves time. New Carthage is a long

way away—we can't afford to take time. We need instant communication....."

New Carthage is an inhabitable planet circling the star, Wolf 359.

Six pairs of twins have been selected so as to study if experiences are simultaneously shared between them rather than transmitted from one to the other. Each twin is being looked after by a foster mother in her early thirties. These genetically engineered twins are produced in an artificial uterus—the sperm and ovum having come from donors.

The experiment involves exposing the twins to a life-size photograph of a gin—the natives of New Carthage, who are cheetah like. A phobia is built up for gins in each of the test pairs. In other words, they are conditioned to react to a make-believe nightmare. In the last lap of the experiment, one twin is shown a holographic slide of the gin in a closed, sound proof room. Does the fear of the gin in one twin arouse similar emotions in the other? This is what John Strecker and his team want to find out. One pair after another is tested but most of them do not show any results. That is, while one is screaming with fear the other is not affected at all.

On Lo and Ti Lo, Nicole's charges, surpassed all the Project Leader's expectations. As On was being shown the gin's image, even Nicole, her foster mother started experiencing strange sensations flowing all through her body. She was terrified and quite illogically screamed out (to nobody in particular) to stop the screening of the gin's image. As Nicole ran into On's room, she found that the child had become a source of energy. But Nicole was only human, her maternal instincts came first. In her desperation, she shook the girl violently and slowly, the warmth came back to On's body and her heart started beating.

John Strecker was not sure what had happened. Nervously, he checked up with Nicole if she too had felt some sort of vibrations going through her body at the time the gin's image was projected and shown to On. Ti, he reported had gone as stiff as a pole and On had done the same. The experiment had been most successful.

ful. Only, Nicole who is all along shown to be a rational, unemotional individual, revolts. She has been a mother of the twins—she abhors the idea of building up and exploiting their fear even if it means a major breakthrough in communication. In order to protect the children from facing such terror once again, she takes the twins and runs away. Revolting at a crucial juncture seems to be quite a trend in Science Fiction stories. Maybe it is the only way to highlight the fact that human beings are after all the most important factors. And that the human mind would continue to be the ultimate decision-maker.

The local people of Outer Angles had heard about the queer 'going on' in Manston House. Some of them had even started looking upon On Lo and TiLo as gods. They give their wholehearted support to Nicole when she runs away with her children to save them from the horrors of the experiment.

Outer Angles is in the suburbs of London—and the weather in early December had normally always been severe. But that year, the season was exceptionally mild. Something queer had certainly happened; the birds, the plants and the animals too were behaving as though it was anything but winter. The vixen for instance was in cub. The villagers were delighted, and were sure that all good fortune was due to the special powers of the twins.

But of course, it is not quite possible for rebellion of any kind to succeed in the year 2096. The rebels are soon hunted down and the experiments resumed.

As the story unfolds, Alex goes through a series of experiences. He meets all kinds of people ranging from the very rustic kind to the very technical, straight-faced, unemotional variety. Also, the various experiences he goes through show us what life and love could be like in the year 2096 A.D. Nicole's influence on him has made him aware of the writings of Mathew Tse—a philosopher of the times. Frequent references to his teachings remind the reader that the human mind is not going to lose the faculty of wondering as to what life, love or the Universe is all about.

The twins also show natural human reactions like today's kids. During the last lap of the experiment, one of the twins stays back on planet Earth with Nicole and the other goes up to New Carthage—or rather stays on Sting Ray Craft—a floating city of the planet with no Mayor. John Strecker had planned that the natives of New Carthage would be shown to On Lo and her twin's reaction to On Lo's horror of the sight would be recorded on Earth. But before all this could happen, even while the acclimatization was going on, an ordinary letter from Nicole arrives. On Lo walks off from the raft to look for her mother. And although she is found, it is on this

occasion that she disappears most mysteriously. She gets transformed into Energy and Alex could swear that she had joined the stars in the Universe. What is more, Nicole reports later that at about the same time TiLo also had vanished.

RATNABALI MITRA

Books Received

1. **INTRODUCTION TO NUCLEAR SCIENCE** by M.N. Sastri, Affiliated East-West Press Private Limited, 104 Nirmal Tower, 26 Barakhamba Road, New Delhi-110001. Pp. 169, Rs. 17.00
2. **COLLECTED WORKS OF MEGHNAD SAHA** edited by Santimay Chatterjee, Orient Longman Limited, 1/24, Asaf Ali Road, New Delhi-110002, Pp. 591, Rs 75.00
3. **FRONTIERS OF LIFE SCIENCES** by Jagjit Singh, Sangam Books (India) Pvt Ltd., 160 Anna Salai, Madras-600002, Pp. 139, Rs 16.00
4. **INORGANIC CHEMISTRY CONCEPTS** by P.L. Soni and Mohan Katyal, Sultan Chand and Sons Publishers, 47/1/23, Daryaganj, New Delhi-110002, Pp. 332, Rs 27.50
5. **FURTHER PRACTICAL MICRO-ELECTRONICS** by Peter Simmons (Available with: B.I. Publications, Promotion Department, 61-63 Lakshmi Building, 4th Floor, Sir Phirozshah Mehta Road, Bombay-400001, Pp. 179, ₹ 6.95)

SCIENCE FOR THE YOUNG (Continued from page 551)

on both sides of the equation to obtain

$$\begin{aligned} 10a + e + 10b + f + 10c + g + \\ 10d + h &= 10e + a + 10f + b + 10g \\ &+ c + 10h + d \\ \text{or } 9a + 9b + 9c + 9d \\ &= 9e + 9f + 9g + 9h \\ \text{or } a + b + c + d &= e + f + g + h \end{aligned}$$

which is the same as the original equation.

Reverting back now to our multigrade, we have on combining the terms in the same manner the equation

$$\begin{aligned} 12^n + 43^n + 65^n + 78^n \\ = 21^n + 34^n + 56^n + 87^n \end{aligned}$$

This gives on rearrangement

$$\begin{aligned} 12^n + 43^n + 65^n + 78^n \\ = 87^n + 56^n + 34^n + 21^n \end{aligned}$$

which is a second order multigrade true for $n=1$ and 2 :

$$\begin{aligned} 12 + 43 + 65 + 78 \\ = 87 + 56 + 34 + 21 \\ 12^2 + 43^2 + 65^2 + 78^2 \\ = 87^2 + 56^2 + 34^2 + 21^2 \end{aligned}$$

This is indeed an unusual multigrade as on both sides the digits 1 to 8 are used once only. Moreover, each side happens to be the reversal of the other.

Below we mention a fantastically unusual multigrade due to late Royal V. Heath, an American magician and mathematical puzzle

artist. This is a second order multigrade ($n=1, 2$) of the form

$$\begin{aligned} 1,118^n + 1,881^n + 8,181^n + 8,818^n \\ = 1,181^n + 1,818^n + 8,818^n + \\ 8,881^n \end{aligned}$$

Interestingly, if we reverse this multigrade we have another, namely,

$$\begin{aligned} 1,888^n + 8,181^n + 0,881^n + 1,811^n \\ = 8,188^n + 8,181^n \times 1,881^n + \\ 8,111^n \end{aligned}$$

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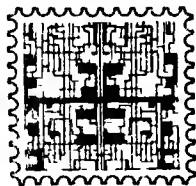
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भारत की संपदा

प्राकृतिक पदार्थ

भारत के प्राकृतिक पदार्थों—वनस्पतियों, खनिजों, प्राणियों के बारे में वैज्ञानिक तथ्यों से परिपूर्ण "वेल्थ ऑफ इण्डिया—रा-मैटीरियल्स" का लगभग 5000 पृष्ठों से परिष्कृत एवं परिबाधित हिन्दी संस्करण प्रामाणिक जानकारी के लिए हिन्दी अकारादि क्रम में, 10 खण्डों में "भारत की संपदा" नाम से सचित्र वैज्ञानिक विश्वकोश के रूप में प्रकाशित हो रहा है। इसके सात खण्ड और दोनो पूरक खण्ड 3432 पृष्ठों में अबतक प्रकाशित हो चुके हैं।

लेख किस बारे में हैं

भारत की संपदा में विशेषज्ञों द्वारा लिखे गये विनिबुद्धी (मोनोग्राफिक) लेख ऐसे खनिजों, जीवों और पेड़-पौधों के बारे में हैं जिनसे औषधियाँ, खाद्यपदार्थ, पेय-पदार्थ, फल, नट और मसाले अथवा वसा, तेल, शाक, सगंध तेल, स्थापक, धूमक तथा चर्वणीय पदार्थ या रंग-रोगन, रेशे और लुगदी, प्रकाशित तथा वन उत्पादों आदि में से कोई न कोई पदार्थ प्राप्त होता है।

लेखों में क्या मिलेगा

वनस्पतियों की सही पहचान और उनके वैज्ञानिक नामों के साथ भारतीय भाषाओं के प्रचलित नाम मिलेंगे। अतिरिक्त जानकारी प्राप्त करने के लिए संदर्भ ग्रंथों की सूची मिलेगी। सब्जियों के उचित उल्लेख के साथ सभाव्य अद्यनन आकड़े मिलेंगे। प्रत्येक खण्ड के अंत में उसमें आये भारतीय भाषाओं के नामों की अनुक्रमणिका (इण्डेक्स) मिलेगी। फसल पौधों के बारे में उनकी खेती, कटाई, भण्डारण, रोग तथा नाशक जीव और उनका नियंत्रण मिलेगा। प्राकृतिक पदार्थों के उत्पादों के भारत में प्राप्ति-स्थान, उत्पादन, आयात तथा निर्यात के आकड़े मिलेंगे।

खण्ड	पृष्ठ	शीर्षक	चित्र	मूल्य (रु)*
प्रथम (अ-औ)	404	723	150	38.00
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तृतीय (ख-न)	450	501	166	36.00
चतुर्थ (प)	430	312	115	83.00
पंचम (फ. में* में*)	391	448	103	60.00
षष्ठ (मे-रु)	400	398	109	80.00
सप्तम (रे-वा)	440	334	108	135.00
पूरक खण्ड				
पशुधन और कृषकट पालन	298	145	125	34.00
मत्स्य और मात्स्यिकी	173		107	49.00

योग, 551.00

अष्टम खण्ड (वाय-सीमे) प्रेस में तथा खण्ड नौ एवं दस प्रकाशनाधीन

* सस्थाओं और पुस्तकालयों को 10% छूट; पैकिंग और डाक व्यय 15 रु अतिरिक्त

यह ग्रंथमाला वैज्ञानिकों, उद्योगपतियों, विद्यार्थियों, शिक्षण और अनुसंधान संस्थाओं, पुस्तकालयों, विकास अधिकारियों तथा जन साधारण के लिए समान रूप से उपयोगी है।

बिक्री और वितरण अधिकारी

प्रकाशन एवं सूचना निवेशालय, सी. एस. आई. आर.

हिससाइड रोड, नई दिल्ली-110012

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SCIENCE REPORTER

DECEMBER 1984
VOL. 21 No. 12

SCIENCE REPORTER

DECEMBER 1984
RUPEE UNIT



COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
(Publications and Information Directorate, New Delhi)

Cover : The flashlight fish,
Photoblephron (Painting by
Biman Basu)

Science Reporter is published
monthly. Publications and Informa-
tion Directorate (CSIR) assumes no
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Editors: S.P. Ambasta
C.B. Sharma
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Annual Subscription

Inland Rs. 10.00
Foreign (By surface mail) \$ 5.00

Phones: Editorial, Production &
Sales—58-6301, 58-6308 56-8385

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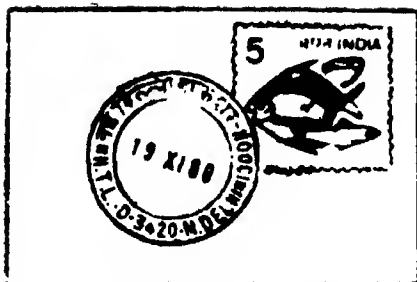
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LETTERS

Fusion Power

Sir, **Heavy water for nuclear power industry** by B.K.S. Nair (S.R., August 1984) was interesting. Although the author has essentially dealt with fusion technique, he has, in the concluding paragraph, briefly alluded to the fusion mechanism and that it can provide an answer to the future energy requirements of human beings.

The explosion of the H-bomb is an example of fusion process, which uses heavy hydrogen and which is essentially an uncontrollable thermonuclear reaction. In spite of tremendous research work done in the last few decades, intricacies of controlled fusion reaction have not been mastered. They are (1) to produce the temperature necessary to ignite a fusion chain reaction—about 350 million degrees; and (2) to hold the temperature in any kind of working system.

Heavy water or D_2O containing heavy hydrogen forms about .02 per cent of water in the oceans and its separation from water is a well-known process. According to Prof. G. Gamow, the total amount of nuclear energy available from the oceans through this process of fusion is 6×10^{21} calories. This energy can last for 60 billion years—much more than the sun is expected to last.

S.K. Gurtu

Simulation and Optimisation Group
'L' Block, New Delhi-110001

The suicidal sound

Sir, In **Funambulus—the Indian palm squirrel** (S.R., Aug 84), Amresh Chander Panday has described some

morphological and reproductive behaviour of the squirrel. I may add something more about the response of the animal to certain types of sound. *F. pennanti* has a peculiar sound philial behaviour for motorcycles, especially those with 2-stroke engines. On hearing sound of a motorcycle, the squirrel climbs down and comes on the road. As the vehicle approaches nearer, the squirrel gets increasingly excited and makes fast zigzag movements on the road near the area of the highest sound vibrations. In this attempt it is often run over.

Is the behaviour of peacock to thunder and of squirrel to whirring of vehicles in any way correlated or is it the impact of fast industrial developments on animals around us?

Risal Singh

Vety. Surgeon

C.V.H. Bhattukalan

Distt. Hissar (Haryana)

Perfect numbers

Sir, In **Some interesting properties of perfect numbers** by P.K. Mukherjee (S.R., May-June 1984), the author has mentioned in first para (p. 275) that 'A total of twentyfour even perfect numbers has so far been known', but it is a very old information. The next three perfect numbers, i.e., 25th, 26th and 27th correspond to $p=21701$, 23209 and 44497 respectively in the Euler's formula for even perfect numbers, viz., $2^{p-1}(2^p-1)$.

The 28th perfect number was discovered in May 1983 at the University of California and is $(2^{86243}-1) \cdot 2^{86242}$. The largest perfect number so far known is $(2^{132049}-1) \cdot (2^{132048})$ and it corresponds to the largest known prime number $(2^{132049}-1)$ which consists of 39751 digits.

Shyam Sunder Gupta

IRSE(P)

Western Railway
Bombay

Prosopis juliflora

Sir, The article ***Prosopis juliflora*** by S.D. Khanduja (S.R., Sept 1984) was good and informative. I have considerably studied ecological and economic importance of this extremely

hardy tree in Thar desert. Besides being an ideal firewood tree having high biomass energy value, it has high fodder value also as its legumes are highly palatable to domestic herbivore animals. The legumes are nutritive having 13% protein and 74% carbohydrate. The plant has notable ecological importance too. Thickets of *Prosopis* give shelter to a large number of vertebrate species, e.g., the hare, blackbuck, nilgai, jackal, wolf, jungle cat and the monitor lizard, etc. They also help in reducing high velocity winds thereby reducing soil erosion. *P. juliflora* is a multipurpose useful tree of aridlands which can play a vital role in development of wastelands for social forestry for ecological and economic importance and utilities.

Indra Kumar Sharma

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Bamboo—the tree grass

Sir, The article **Bamboo—the tree grass** by M.S. Haque (S.R., September 1984) was interesting and informative. The fact that bamboo is generally propagated vegetatively through rhizomes, offsets or culmcuttings has been dealt with in detail. I would like to add more.

As is well-known, many tropical bamboos flower gregariously and seed after long intervals. They are hence mostly propagated vegetatively using rhizomes and offsets. But such materials have some disadvantages since they are difficult to extract, bulky to transport and inadequate for large-scale artificial regeneration. Culm and lateral shoot cuttings, on the other hand, would be relatively much more convenient and economical to use if they could be induced to root and established as new plants.

Seethalakshmi *et al.* (1983) working on *Bambusa balcoa* Roxb., a commercial species, obtained success after pretreatments with some growth regulatory substances. They have reported that besides auxins, some non-auxin substances like coumarin could induce bamboo branch cuttings to root. Even better response was

(Continued on Page 636)

GLITTERING of "mystery meat", glowing of freshly rotten woods, burning of sea, flash of fireflies, light emitted by glowworms and allied organisms during night or in dark had always been a point of great curiosity till the secret behind all these was unfolded by Robert Boyle in 1668. He observed that the light in the putrefying wood or decomposing fishes disappeared in the absence of air, which meant that the light emission was limited to the availability of oxygen. Light emission by living cells or organism is widely known as bioluminescence. This word has been coined from the Greek word, *bios*=life, *lumi*=light and may be defined as emission of visible radiation by an enzyme-catalysed reaction. The light emission takes place in an aqueous environment at near neutral pH, and is not accompanied by heat, hence is often called cold light.

The most striking feature of bioluminescence is the diversity of organisms that have developed the ability to emit light. They include some bacteria, fungi, protozoan (flagellates), sponges, coelenterates, ctenophors (small jellyfish-like animals), annelids, marine worms, squids, centipedes, millepedes, crustaceans, molluscs and insects, etc. Fresh water organisms, though closely related to marine light emitters, are not luminiscent except *Latia neritoides* which spends its entire life in fresh water. The other salient feature is its absence in higher animals such as amphibians, reptiles, birds and mammals, except a few species of fishes where too it is merely due to the presence of symbiotic luminiscent bacteria.

The interesting practical use of such a light was made during Second World War by Japanese soldiers. They used the dried powder of *Cypridina* (Fig. 1, a marine crustacean) as a source of low intensity light when they did not want to run the risk of using flash light. A small quantity of the powder, on being moistened with saliva on palms, produced enough

LIGHT PRODUCING ORGANISMS

DHAN PRAKASH
P. S. MISRA

The most striking feature of bioluminescence is the diversity of organisms that have developed the ability to emit light.

light for reading a map or a message in dark.

The most attractive luminous organism is the larval form of a South American beetle *Phrixothrix* which bears 11 pairs of luminous green spots along the sides and a pair of red spots on its head. When on rest at night, only the red spots shine giving it the appearance of a burning cigarette, but while crawling, the green spots are switched on. The whole animal resembles a moving train, hence it is referred to as the "rail road worm".

Other eye catching luminiscent organism is the Click beetle *Pyrophorus noctilucus* (Fig. 2) which is decorated with two oval greenish spots, one on each side of the front part of the body. The spots, while emitting light, resemble an automobile head light. The insect is also called "automobile bug".

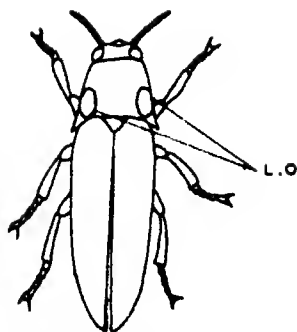
Photuris pennsylvanica (Fig. 3), a common North American firefly, has a heart-shaped luminiscent area on the ventral side of the last three abdominal segments that emit orange light. The allied Indian firefly (Hindi : Jugunu) that emits light in dark nights of rainy season is known as *Photinus*. The light of firefly is a mating device to attract the opposite sex. Light signals presence of a waiting female in the grass. Recognition between a male and a female depends

on the colour and time interval of the emitted light.

The luminous dinoflagellates, *Gonyaulax*, *Noctiluca*, *Pyrodinium*, etc. also emit light. The glowing of water, popularly known as "burning of the sea", and "red tides", which presented a baffling mystery to fishermen and other observers for centuries, is due to the presence of a large number of dinoflagellates. On being disturbed, they emit light of brown, blue and yellow colour on the surface of sea.

Light produced by these organisms can be differentiated into three main morphological patterns:

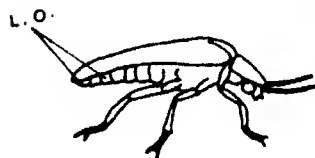
(1) *Extracellular*. In this type, the light producing reaction takes place outside the body of the organism. As in *Chaetopterus* (annelid), the light producing organs are in the form of glands called photocytes which are found in the integument along mucous cells. Secretion of these glands is passed out in the surrounding water, which on interaction produces a stream of light, running throughout the length of the organism. Almost a similar reaction takes place in *Diplocardia*, *Cypridina* and *Pholas dactylus* (Fig. 4). In certain cases, e.g. *Renilla* (annelid), light emission is under nervous control. The light in the sea that resembled moving candles and which Columbus saw on his



PYROPHORUS

L.O., LUMINESCENT ORGANS

Fig. 2



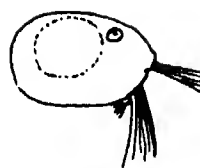
PHOTURIS

Fig. 3

first voyage to the New World was due to the presence of moving luminiscent *Odontosyllis* (annelid). Light is produced as a mating signal.

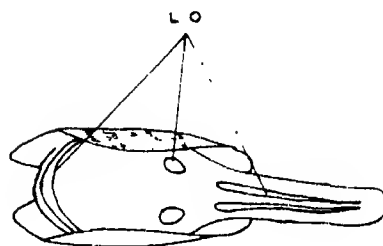
(2) *Intracellular*. Here the light producing reaction takes place within the cell or organism, e.g., in *Noctiluca* (Fig. 5, protozoa) light is produced by the secretion of two types of granules which are arranged along definite strands of cytoplasm radiating from oral groove and extending towards periphery. Interaction of the secretion of these granules in presence of air emits light which gives the tiny creature the appearance of a shining fan. The "red tides" of the sea are mainly due to the glow of these dinoflagellates. The other examples are *Gonyaulax*, *Arenicola*, *Sergestes*, *Photuris* and *Phrixothrix*, etc.

(3) *Special tissues*. In this type, the light is actually emitted by the bacteria as, for instance, in *Photoblepharon* (Fig. 6, a fish), under each eye there is an oval white spot which is richly supplied by blood and harbours luminiscent symbiotic bacteria. These complex structures are called photophores and are provided with devices



CYPRIDINA

Fig. 1



PHOLAS DACTYLUS

Fig. 4

for turning on and off the light. The light emitted from photophores is used as a flash light to find out track in dark deep sea. Other examples are *Anomalops* (a bony fish from Meleya), *Heteroteuthis*, *Loligo* (squids). In squids, luminiscence is a protective device, a lure to the deep sea angler fishes.

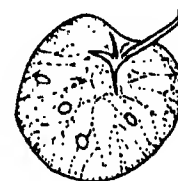
Evolution and bioluminescence

It is believed that the earlier forms of life on earth developed in the absence of oxygen. Hence, these organisms were referred to as anaerobes. When oxygen slowly appeared, it was toxic to them. Therefore, it was necessary to get rid of it quickly. The most efficient way to remove oxygen chemically is to reduce it to the form of water. It has been presumed that the most efficient reducing agents were those organic compounds which were already a part of the hydrogen transport system in the primitive anaerobes. This process, conversion of oxygen into water, is an exothermic reaction which produces enough energy in a single quantum. This energy, on exciting the organic mole-

cule, appeared in the form of light. From this hypothesis, it has been further concluded that all successful oxygen removing organisms would have been potentially luminiscent. During subsequent evolution, the anaerobic organisms evolved in such a fashion that they could use oxygen to meet their metabolic requirements. This led to emission of light as a by-product of their metabolic reaction. However, it may be mentioned that in most cases bioluminescence is dependent on a non-essential enzyme system.

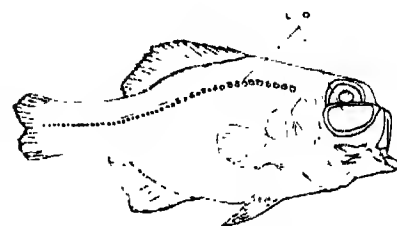
Physiology of bioluminescence

Light emitted in bioluminescence is always in the visible range (400nm-800nm) of the light spectrum which varies from organism to organism. This light emission is based on a chemical reaction catalysed by an enzyme system created by living organism. The preliminary information is based on experiments of a French physiologist R. Duboi (1887) on *Pholas dactylus*, who observed that cold water extract of the mollusc emitted light for several minutes. When emission had ceased it could be restored by adding washings of fresh clam in hot water after cooling the



NOCTILUCA

Fig. 5



PHOTBLEPHARON

Fig. 6

It is important to note that luciferin is a generic term which does not apply to any specific chemical structure. Although luciferin structures may vary widely, it has been found in a number of instances that luciferins isolated from diverse animals may be identical. Similar observations have been made for the luciferases. One of the interesting properties of luciferase proteins is their ability to manipulate large amounts of energy and to catalyse the creation of an electronically excited state. In the excited state, molecule is not stable, therefore, the excited electrons return to the ground state and energy is emitted as light.

The biochemical reactions which take place during light emission of some organisms are .

Once luciferin is formed, the only requirement for bioluminescence *in vitro* is oxygen and luciferase. As shown in Fig. 7 - 2, luciferase catalyzes oxidation of luciferin to produce light, CO₂ and oxyluciferin.

Luminiscence of firefly (*Photuris*) is a simple redox reaction involving molecular oxygen and a complex organic substrate luciferin 4. In addition to luciferase enzyme, the reaction also requires a continuous energy supply substance, adenosine triphosphate (ATP). Cold water extract of firefly, if allowed to stand until the light emission disappears, can be restored to more than its original intensity by addition of ATP. Another interesting feature of this cold extract is that it gives yellow-green light in neutral medium, but the emitted light is red if it is made acidic. The overall chemical requirements can then be expressed as in Fig 7-3. The quantum yield of bioluminescence is approximately one, both with respect to oxygen and luciferin. There exists a wide range from species to species in the colour of firefly light. This variation has been demonstrated to be directly related to differences in the enzyme, not in the substrate.

The source of light in bacteria is a side reaction of oxidation and reduction where energy comes from nutrients. In this process, hydrogen atoms (or equivalent electrons) are removed from food and passed on in reaction. Finally hydrogen is accepted by oxygen to produce water. In this sequence, energy is removed from reactions and stored in the form of ATP. When reduced flavin mononucleotide (FMN) 8



reacts with luciferase and oxygen in presence of long chain aldehyde, light is emitted. Here flavin takes the role of luciferin. The reaction products are oxidised FMN and an as yet unidentified aldehyde derivative. It was proposed that aldehyde acted only to change the conformation of the quantum yield of the reaction. The intensity of luminescence may be increased by addition of long chain aldehyde like dodecanal and oxygen

Emission of light completely ceases in absence of oxygen. The overall reaction can be represented as in Fig. 7-5.

In case of *Lata* bioluminescence, besides luciferin, luciferase and O_2 , a so called "purple protein" is an unusual requirement. Here luciferin 9 contains a β -ionone ring like vitamin A and a side chain with an enol formate linkage. It was suggested that luciferin 9 first combines with purple protein

prior to its involvement with luciferase in the light producing reaction. The overall reaction may be represented as in Fig. 7-6.

In most bioluminescent reactions exactly one light quantum is emitted for each molecule of luciferin consumed i.e., the light production is 100%. The term cold light for bioluminescence is correct.

LETTERS (Continued from page 632)

obtained when this substance was used in combination with Indole Acetic Acid.

Surendran *et al.* (1983) working on thorny bamboo *Bambusa arundinacea* (Retz). Willd reported that chemical treatment could induce and enhance rooting ability of culm cuttings in this species. Besides, such treatment also helps to widen the period for root induction and propagation. It was further noticed that the

same concentrations of the same chemical evoked different response during different seasons. This was supported by the findings of Nanda (1970) working with auxins

According to Surendran *et al.* (1983) boric acid may be added to the list of non-auxin root promoters. It is comparatively a much cheaper chemical and more readily available. Phenyl boric acid is reported to form strong complex with sugars and

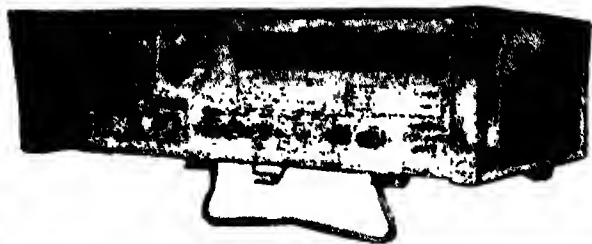
greatly influence root growth.

It would thus appear desirable to repeat the rooting trials with boric acid along with sugar solution and auxins for improved rooting in bamboos and forest tree species, like teak.

R. Synrem

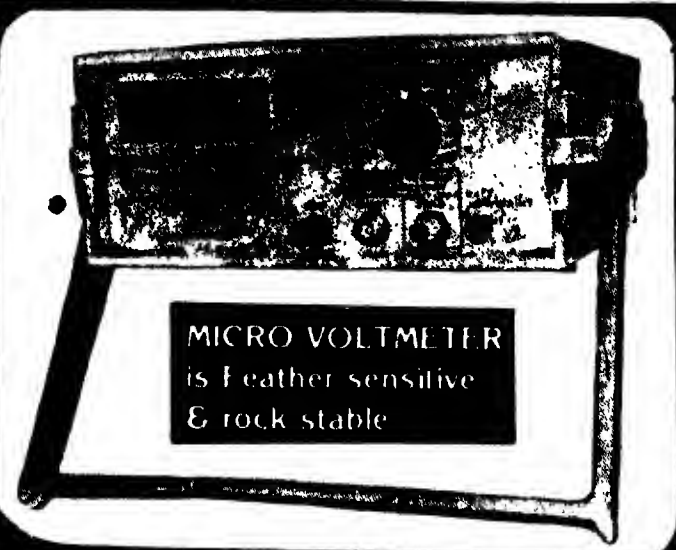
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LIGHTNING AND ATMOSPHERIC NOISE

R. BHATTACHARYA A. B. BHATTACHARYA

Lightning is a problem. It affects power lines, buildings, machines and telecommunication systems. It damages aircraft, kills living beings and causes fires and accidents

A LIGHTNING flash can be regarded as an impulse generator with energy components extending over a wide range of frequencies. Within any specified band, its nature and intensity at a place therefore depend on the power of electromagnetic wave, the distance and height of the flash, orientation of the flash with respect to the direction of propagation and propagation characteristics of the path for specified frequency, time and location.

Physical research on lightning and practical application of results obtained are connected. Lightning discharges affect power lines, buildings, machines and telecommunication systems. They can cause damage to aircraft, they kill and injure living beings and cause fires and accidents.

By definition, a complete lightning discharge is a flash, while a stroke is a partial discharge of low luminous intensity. If luminosity persists for more than 40 msec in the channel, it is called long-continuing luminosity. A stroke followed by such luminosity is called long-continuing stroke. Similarly, a stroke followed by continuing luminosity of less than 40 msec is called a short-continuing stroke. A

stroke whose luminosity decays abruptly is a discrete stroke. It is convenient to distinguish between the visual flash and its component strokes. General results show that each flash contains 1-42 'main' strokes and that each main stroke is preceded by a 'leader' stroke. The leader strokes proceed downwards from the cloud. For most of the cases, the leader of the first main stroke proceeds in steps and shows considerable branching. When the leader stroke is at a height of 5 m-50 m from the ground, a streamer from some point connected to the earth goes up to meet it and, then, the upward main stroke commences. This is much brighter than the leader stroke and it follows the same path. Usually, the leader strokes, except the first one, do not show steps but follow the same track as the first main stroke. Such unstepped leaders are known as dart leaders. Since a dart leader moves faster than a stepped leader, the ionization near the top of the leader is fresher for a dart leader than for a stepped leader at the time when the main stroke starts. Hence the main stroke to a dart leader may be more rapid than to a stepped leader.

Electromagnetic energy from lightning

Many kinds of measurements have been made and developed to study the phenomenon of lightning discharge. Of these, optical, photoelectric, electrostatic and electromagnetic methods are in use all over the world. The electromagnetic energy radiated from lightning propagates through the space between the ionosphere and the earth. Some of the energy penetrates ionosphere into the exosphere which is guided by the geomagnetic line of force and is reflected back to the source again along the same geomagnetic line of force. Since the exosphere consists of a weak plasma embedded in a magnetic field, it is dispersive. Atmospheric pulses, during their movement through the exosphere, become whistlers from which the existence of protons and also the density of electrons are derived and determined.

Lightning discharges are classified into two types—the intra-cloud discharges (i.e., the discharges that occur within the cloud) and the cloud-earth discharges (discharges striking the ground). The intra-cloud discharge also changes the electric field and it is somewhat different from the cloud earth discharges. Due to cloud discharges, there is a change in the slow electrostatic field which is positive at near distance (5 km-10 km) and negative at far distance (10 km-20 km or more). So, the study of electric field close to a lightning discharge is valuable for investigating its mechanism.

The frequency spectra of atmospherics, i.e., the intensity variation of atmospherics with frequency are useful for studying wave propagation, propagation of atmospherics and the mechanism of lightning discharge. However, it is very difficult to obtain frequency spectra at various distances from the source, at various stages of lightning discharges at various geographical features and under various meteorological and seasonal conditions. For these reasons, even now knowledge of frequency spectra is meagre. A Kimpara of Japan normalized all the data at a distance of 10

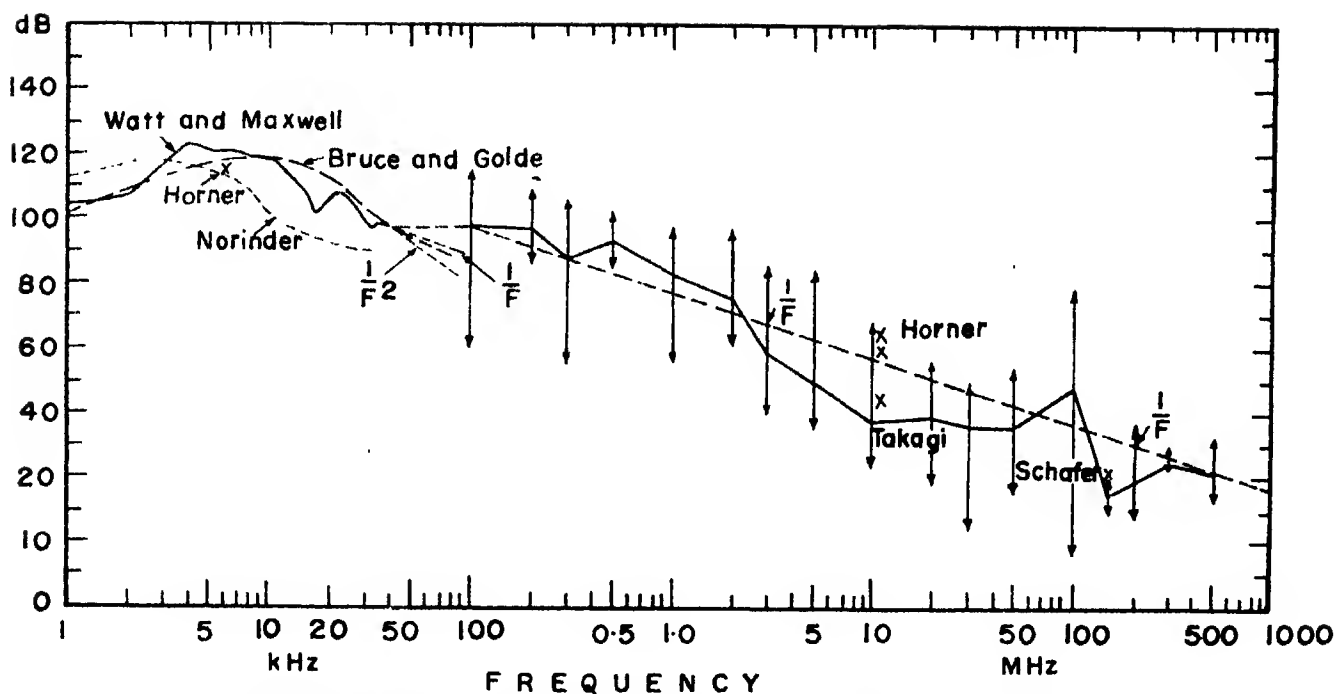


Fig.1. Spectrum of the field intensity of atmospherics in dB above $1 \mu\text{V/m}$ at a distance of 10 km (Kimpars, 1965)

km for a receiver bandwidth of 1 kHz and found the frequency spectrum as shown in Fig. 1. Since the methods of measurement and the characteristics of the apparatus were different, the curve in Fig. 1 is not completely reliable. It only shows a general tendency.

It is evident now that the characteristics of atmospherics which define their frequency spectra depend on the configuration and development of thunderclouds. They exhibit variations according to the seasonal and meteorological conditions and geographical features.

In cloud-ground discharges, hybrid flashes are commonly observed. In multiple flashes which constitute 86% of all C-G discharges, the discrete and hybrid flashes occur in the proportion 50:50 (approx.) Generally, the long continuing stroke does not occur either as a single stroke or as the initial stroke of a multiple flash. A comparative result of luminous events of a discrete and a hybrid flash recorded by N. Kitagawa of Japan by a moving film camera and of the electric field and the electric field change records is presented in Fig. 2. The actual variation of the electric field is represented by the electric field record, while the electric field change record shows the rapid components

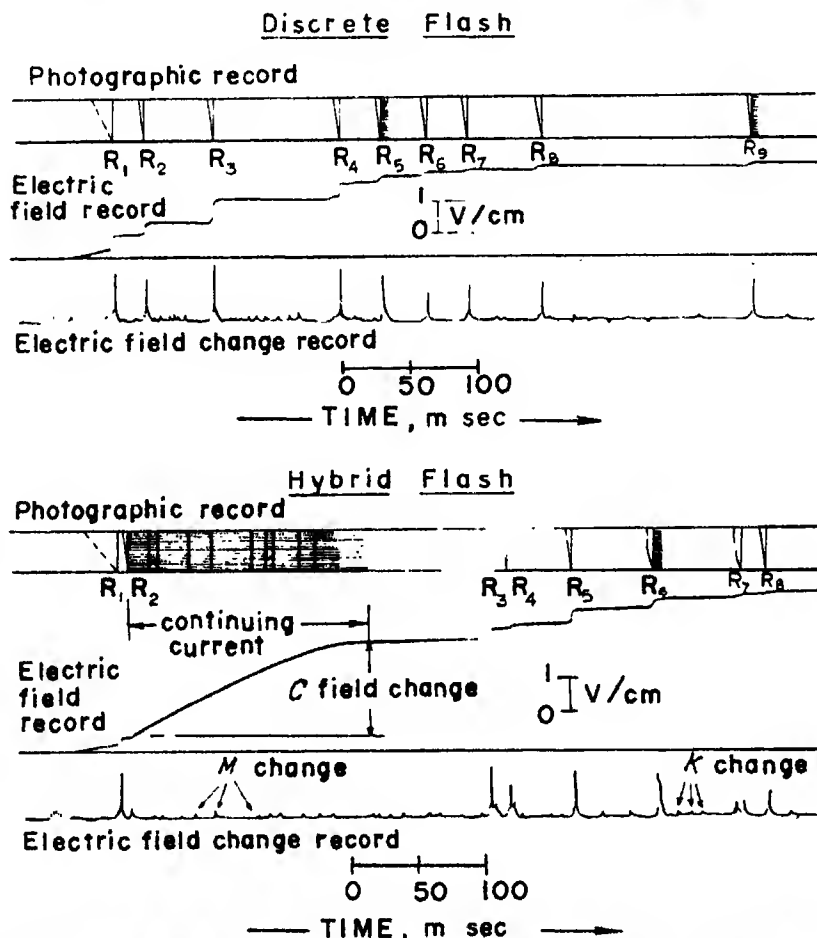


Fig.2. Typical samples of simultaneous photographic, electric-field and electric-field-change records due to cloud-to-ground discharges (Kitagawa, 1965)

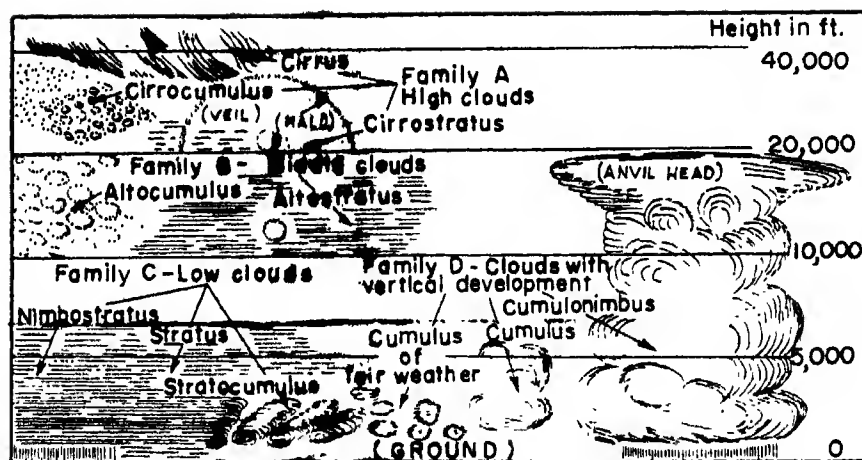


Fig.3. The ten basic cloud groups classified according to height and form

through the use of an antenna with a high amplification and a short time constant.

Electrical characteristics in clouds

For a close study, a classification of the various types of cloud is required. The system adopted internationally is based upon the general shape, structure and vertical extent of the cloud, and its altitude. The clouds are mainly classified into ten basic groups or genera, the characteristics of which are shown in Fig. 3.

It is believed that the charges are arranged in such a way that one type of charges is concentrated on one side and the second type on the other side in a cloud. Such a cloud is called bipolar; it is taken to be of positive polarity if it has positive charge at the top, and of negative polarity in the reverse case. A complete diagram of potentials, slopes of which give potential gradient and the curvature gives the space charge, can provide a consistent account of the electrical states of the cloud and of the regions above and below it. To draw such a diagram in detail, it is necessary to solve a complex system of differential equations. The solution can give the variation of precipitation charge with height, convected charge, number of small ions of each sign and potential. Generally, qualitative results are used for meaningful conclusions. The phenomenon of charge separation within a cloud depends upon the various physical processes occurring within

the cloud. An important factor in the processes involved is temperature. The temperature 41°C appears to be the fundamental temperature in cloud physics and is the lowest temperature at which water droplets remain suspended and below which they freeze spontaneously. Electrical phenomena are observed in both cumulonimbus (thundercloud) and nimbostratus (shower) clouds, but the intensity is much less in the latter than in the former.

Recent trend in studies relating to atmospheric electricity is mainly to determine meteorological factors which control its variations. The surface potential gradient at land stations within the Austausch (borrowed from German; meaning exchange) layer is dependent on the resistance of the lowest layer of the atmosphere. The height of the top of the Austausch layer depends upon meteorological conditions, particularly upon variation of temperature with height and may have any value upto about 3 km. So characteristics of air mass such as its tiny dust particles, pollution content, stability and moisture content influence variations of potential gradient during fair and disturbed weathers.

During the passage of a thundercloud near an observation site, W-type variation of the potential gradient is observed most frequently. This leads to electric charge distribution in a thundercloud of positive polarity with a small pocket of positive charge in the lower centre of the main negative charge.

In India, measurements of atmospheric potential gradient have been made at Pune since 1930. The nature of variations of electric field strength was studied there at the ground level during the International Quiet Sun Year (IQSY, 1964). These observations were compared with those made during the International Geophysical Year (IGY, 1954) and earlier during 1930-1938, as well as with the results obtained at Bombay during IQSY and IGY.

Sources of atmospheric noise

It is by now well-known that there are different types of lightning flashes. There are lightning flashes called ground flashes in which electrical discharges strike the ground, those in which discharges occur within the cloud are called intra-cloud flashes, or briefly cloud flashes, and those occurring between the cloud and the air. In all types of flashes there are electrical discharges within the cloud. These discharges within the cloud are responsible for radiations giving rise to a noise burst at any frequency. In tropical countries, ordinarily, the cloud base is at a height of about 3 km above the mean sea level. Radiations due to discharges within the cloud can be received upto a distance of about 300 km by the direct ray. So all sources present within a distance of about 300 km from the point of observation are called local sources. The days of a year on which such local sources are found to be present are called days of local activity. Experimental observations have revealed that the number of days of local activity is roughly three times the number of thunderstorm days, suggesting that the local sources are responsible for the highest amplitude noise bursts. Sources present between 300 km to 1000 km are called nearer sources. Radiations from such sources in the Medium Frequency (MF) and High Frequency (HF) bands are probably directed via the ionosphere. As a result, reception of these radiations depends on propagation conditions via the ionosphere and hence such receptions may not be possible at certain hours of a day and at some definite frequencies. Sources beyond 1000 km are called distant sources where a large number

of sources are at play at any instant. When propagation conditions at any given frequency are favourable, the signal from such sources can appear as noise in the receiver. Hence, a very large number of noise bursts of varying amplitudes should be received from different sources. It therefore follows that noise originating in such sources would correspond practically to continuous noise.

The noise due to local sources is always in the form of distinct and well-separated noise bursts. The noise due to nearer sources is mostly in the form of distinct noise bursts. When a large number of nearer sources are active at a time, the number of noise bursts received per minute is very large. This usually gives rise to noise almost of the continuous form. Noise may be considered as a complex phenomenon. Fluctuation noise arises from several known factors either in the equipment or in the channel. For the treatment of this noise mathematical models are already available. The other form of noise, known as impulsive noise, appears

intermittently at random intervals and for random durations.

Noise measurements in India

The geographical location of the land mass of India makes it one of the most suitable countries for studies of atmospheric noise in terms of lightning flashes. The experimental work done over the last two decades at different parts of India is of relevance to three major areas. They are characteristics of the random processes, characteristics of tropical thunderstorms and characteristics of atmospheric radio noise. A brief summary of the results obtained for each of these areas by different authors is given below.

(i) Duration of noise bursts, amplitude of a noise burst, number of noise bursts and time interval between successive noise bursts at a certain frequency follow the log normal distribution, i.e., when plotted in terms of the logarithms of their X values. A Poisson distribution is obtained for at least some of the random events and

so conclusions drawn have been carefully rechecked. It is found that log-normal law is an approximate representation and not an accurate one. The accuracy realized is of the order of 90% which is, of course, adequate for most engineering evaluations.

(ii) A lightning discharge is continuous throughout the activity of thunderclouds though the flashes are of different types. Cloud flashes account for the largest number. Most of them cannot be seen visually. Whenever a thunder is heard there are about 10% ground strokes, much less than the percentage found in temperate regions. The median value of the peak rate of flashing during the activity of a thundercloud is 8/min and the duration of a flash is about 500 msec. The maximum activity of land storms is found to occur in afternoon hours, while it happens in premidnight period over oceans. The lifetime of a convection cell has a median value of about 30 min, similar to that reported from experiments in temperate zone. The median duration of the life of an active thundercloud is about

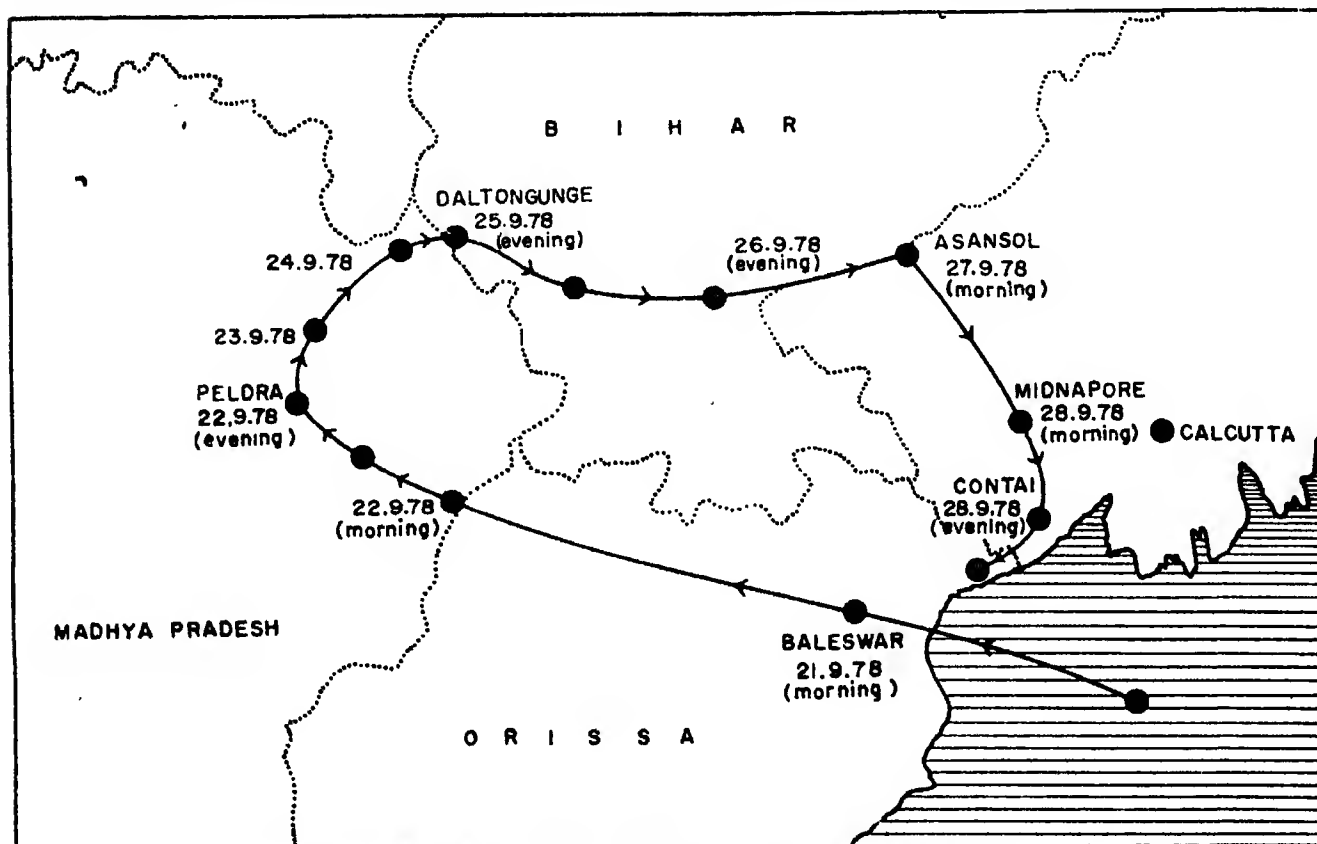


Fig.4. A schematic diagram showing the track of the depression

3 hr, very much higher than the values reported from temperate regions.

(iii) The noise data required for different communication services have been furnished for the whole land mass of India through a set of three data sheets and a map of India showing days of local activity in different regions in the four different seasons. Atmospheric noise in India consists of noise bursts arising from the local or nearer sources. The other interferences due to distant sources contribute to a background which has been evaluated and included in the article. Very High Frequency (VHF) noise radiation due to lightning flashes can travel to distances of the order of 500 km via the sporadic E-layer or by troposcatter.

Conclusion

Studies on atmospheric noise were initiated by the pressing need for long-range navigation system, long distance communication and worldwide frequency standards. Prompted by these needs extensive theoretical and experimental studies of radio propagation are, in fact, being made in recent years, by employing electromagnetic energy radiated by a continuous wave transmitter. While theoretical studies are quite comprehensive, experimental studies are handicapped by the rather limited power of such transmitters, particularly when propagation over long distances is taken into consideration. On the other hand, studies based on harnessing of results of atmospheric characteristics offer a distinctive advantage over the continuous method for the following reasons: (i) the power radiated by a source of lightning is enormous, being of the order of 1000 kW. (ii) the spectrum of the

source radiations extends over a wide range of frequencies and facilitates spectral studies of radio propagation, and (iii) the propagation over long distances is relatively easily detectable.

Experimental investigations by applying continuous wave transmission are particularly impossible at Extremely Low Frequency (ELF) band. Further, as the sources of activity are distributed over a wide region, interference effects between the ground wave and the ionospherically reflected wave are not likely to be present in the integrated field intensity of atmospherics. So the variations there represent those of the ionospherically reflected wave alone.

General features of the world distribution of integrated noise power have been determined during the IGY by a network of sixteen stations distributed throughout the world. However, such studies were confined to the measurement of the average noise power within a 4 hr time block. As a result, the detailed features of the integrated noise occurring within the time block can be smoothed out. Further studies are needed in the world distribution of noise employing, preferably, time blocks of shorter durations such as a 1 hr. block in order to explore true nature and the origin of the latitude and longitude dependence of the integrated noise.

Some special characteristics can also be investigated from the atmospheric noise. For example, records of Very Low Frequency (VLF) atmospherics over Calcutta during torrential rainfall due to violent monsoon depression in 1978 by A.K. Sen, S.K. Sarkar and A.B. Bhattacharya of Calcutta show distinct long period fading both at day and night. The depression concerned has got an early history of development starting

outside West Bengal on 21 September 1978. The origin of the depression was in the Bay of Bengal and came through Orissa, Madhya Pradesh and Bihar, as shown by the schematic diagram (Fig.4), to West Bengal (Asansol) on 27 September in the form of a cyclone in association with heavy and widespread rain. One would expect at a long period fading similar to that of ours if the observing stations are located in the vicinity of the track. A simultaneous multistation study at such times would be informative.

Recently, attempts have been made in some countries to study thunderstorm activity with the aid of lightning discharge counters which count the number of flashes per second. From a careful measurement of the electric field, the charge and size of droplets in cloud through all stages of the cloud life cycle, one can learn much about the transfer of electronic charge from smaller droplets to larger drops. This would tell us particles of which size constitute the fundamental charge carriers in the cloud, how charge is generated and how charge of a magnitude sufficient to produce lightning flash is accumulated in cloud. Many questions which are still unanswered await improvement of the existing instruments and techniques for satisfactory solution.

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GLIMPSES OF ANCIENT HINDU SCIENCE

INDU BHUSHAN SHARMA

For the ancient Hindus science was not only pursuit of idealism or the seeking of truth in the laboratory, but constituted an essential and inseparable part of their daily life

THE foundation of Hindu philosophy has been the discovery of truth. On the basis of their experimental knowledge, the ancient Hindu philosophers propounded theories which are in remarkable agreement with modern science. There seems to be no area of study which has not been explored by them. Whereas subjects like philosophy, religion, politics, economics, and languages received attention to the extent of influencing world civilization, chemistry, medicine, physics, astronomy and mathematics were not neglected in any manner whatsoever. The ruins at Mohenjo Daro and Harappa reveal that, as early as 3000 BC, the ancient Hindus lived a very organised life. They planned cities, built brick-houses and used metals like gold, silver and copper. For the ancient Hindus science was not only, pursuit of idealism or the seeking of truth in the laboratory, but constituted an essential and inseparable part of their daily life. The scientific pursuits were channelised for welfare of the society. Purification of metals, diagnosis of diseases and preparation of medicines, dyeing and textile industry, fixation of calendar of days, weeks, months and years were the outcome of their highly sophisticated scientific work. Origin of matter, creation and development of universe, and other scientific questions have been raised and discussed in Hindu literature.

Religion and science developed simultaneously and both had reciprocal bearing on each other. A conversation between Devarshi Narada, the seer supposed to be a messenger between the gods and men, and Sanat Kumhar, a sage of supreme knowledge, in *Chandogya-Upanishad* testifies to it. When Sanat Kumar asked Narada to state what sciences and arts he had studied, Narada's reply included astronomy (*nakshatra-vidya*) and arithmetic (*rasi-vidya*). Kannada, the founder of *Vaisheshika* theory, recognising the supremacy of matter has nicely developed its correlation with life and immortality. Discovery of mercury and sulphur and their utility in medicine was linked to religion by Ayurvedic philosophers.

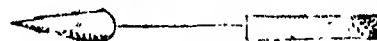
Medicine and chemistry

The Indian system of medicine—Ayurveda—has its origin in the *Vedas*. Ayurveda is considered as an appendix to the *Atharva-Veda*. Hindu philosophers understood anatomy and physiology as early as 800 BC. Even today's physicians and surgeons can learn from their descriptions. Ayurveda diagnoses illnesses as disorders in humours like air, water and blood. *Atharva-Veda* and *Rig-Veda* give diagnosis of numerous such disorders and their treatment. In *Atharva-Veda* there are descriptions of 78 plants and their medicinal uses, which also find mention in Charak

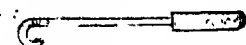
and *Sushrut Samhitas*. Charak, Sushrut, Dhanvantari, Baghbhat, Nagarjun, Govindacharya, Yashodhar, Pran Nath and Kayaach Chamund are some of the great names in the Indian systems of medicine who excelled in the field. Millions of people the world over are still reaping the benefit from their discoveries and findings. Charak in his *Samhita* has drawn up a list of diagnoses of a number of diseases and given their treatment. He classified over 200 plants and numerous minerals like blue pyrites, calamine, quartz crystal and has described their properties. He suggested antidotes for poisons and treatment for snake bites and stressed the use of colloidal form of medicines as they were more effective. Still earlier (circa 1000 BC) the Brahman-literature gives account of highly sophisticated surgical and



KARAPATRA SHASTRA



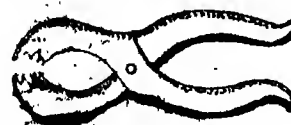
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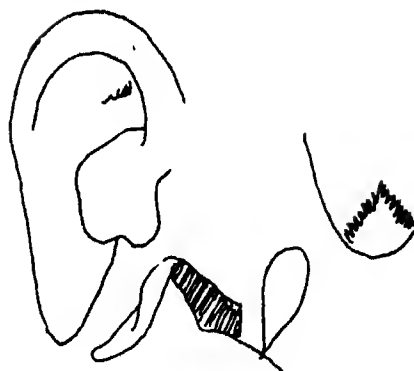
SINHAMUKHA YANTRA

Fig.1 Some of the sharp and blunt surgical instruments described by Sushrut

NEMISANDHANAKA



GANDAKARNA



LIP-PLASTY



Fig. 2. Sushrut's technique of ear-plasty and lip-plasty

medical treatment by the Ashwani Kumars.

Numerous alcoholic products were known in the days of Charak, and acids and bases were prepared and used as medicines. A mixture of nitric acid and hydrochloric acid, probably aqua regia, was also known in those days. Sushrut has mentioned the use of medicines to produce insensibility to pains. Sushrut *Samhita* describes more than a hundred surgical instruments (Fig. 1) and discusses surgical operations. In his time plastic surgery was also in use and he has written of grafting upon a torn ear portions of skin from other parts of body (Fig. 2). In surgery, Sushrut has stressed the need of sterilisation of surgical instruments before use. Besides surgery, he has given diagnoses of more than a thousand diseases and prescribed their medical treatment. Pulse reading and urine analysis were also recommended for the diagnosis of diseases. Sushrut classified plants into 37 families and poisons into two groups namely *Sthavar* and *Jangam*. The former are those obtained from minerals while the latter from living organisms. Hindu physicians had the knowledge of vaccination even before

Sushrut. Baghbhat (600 AD) and Yashodhar (1300 AD) have given accounts of calomel (mercurous chloride) and its use for syphilis.

The processes of fermentation, distillation, calcination and sublimation were well-known in the days of Charak, Baghbhat and Chanakya. Chanakya in his *Arthshastra* has given a detailed description of alcoholic preparations and their uses. In his days alcohol was prepared and distributed by the State. Charak, Sushrut, Baghbhat, Chamund and Pran Nath have given in detail methods of purification, properties and uses of sulphur and mercury in different fields of medicine. Baghbhat, Yashodhar and Kayasth Chamund have described five different types of sulphides of mercury with varying effects over a range of diseases including leprosy.

The iron pillar at Qutab (Delhi) standing rustless for centuries gives an indication of ancient Hindu chemist's knowledge of metallurgy. Three centuries before Christ, King Porus is said to have chosen 30 pounds (15 kg) of steel, instead of gold or silver, for presentation to Alexander. Description of metallic ores, their purification

and conversion into metals and metallic salts can be found in the *Vedas*, *Puranas*, *Upnishadas* and many other Hindu texts. *Rasarnav* gives a detailed description of the flame tests for metals; an important method used in today's laboratories.

Atomic theory of matter

Charak propounded the theory that a body is made of innumerable atoms which are very small in size. Kannada, the founder of *Vaisheshika* theory, said that matter was composed of atoms which were spherical, very small in size and invisible to the naked eye; by the combination of these atoms, dust particles visible in the sun-beams were formed. According to Udhayanacharya, the existence of the universe lies in the motion and interaction of these atoms.

Gautam in his *Nyayadarshan* held that although the atoms were very small in size, they were further divisible. Jain philosophers taught that all atoms are of the same kind but produce different effects by diverse modes of combination. Kannada held that light and heat were varieties of the same substance while Vachaspati interpreted light as composed of tiny particles, emitted by objects, striking the eyes.

Astronomy and algebra

Astronomy in India probably developed with the sole aim of observation



Fig.3. Sushrut's technique of removal of skin flap for doing rhinoplasty

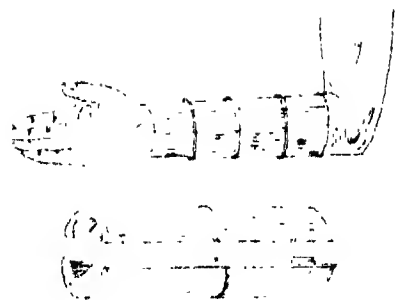


Fig. 4. Use of bamboo splint for fractured bone

of movements of heavenly bodies for fixing dates of religious festivals. In order to make calculations in astronomy various systems of mathematics and geometry were developed. The Hindu calendar is of twelve months, each month of thirty days, inserting an intercalary month after every five years. The days of the week were also fixed.

Surya Sidhant describes the earth as spherical which looks flat because human sight can go only upto a limited distance. However, it contended that the sun also revolves. Aryabhat held that the sphere of stars is stationary while earth revolves and is spherical in shape. He could also explain the eclipses. The Hindu philosophers also knew with great accuracy the diameter of the moon.

The *Vedanga Jyotisha* (1200 BC) says that mathematics has a place in science equivalent to the one which crests have on the heads of peacocks or gems on the hoods of snakes, giving it the highest place of honour amongst the sciences. Indian mathematicians gave the most valued systems to the world, viz., the numerals and decimal system. Moreover, it was they who discovered the use of zero.

In *Yajurveda Samhita* systematic lists of numeral denomination from one to ten billion are given. These denominations are in multiples of 10. A similar reference is available in *Lalitashavra*, a Buddhist work of 1st century BC where a dialogue between the mathematician Arjuna and Prince Gautam (Bodhisattva) is given. On being asked by Arjuna how the counting proceeded beyond the *Koti* (100,00,000), Bodhisattva replied that

a hundred *Koties* made an *Ayuta*, a hundred *Ayutas* made a *Niyuta*, a hundred *Niyutas* a *Kankara*, and so on. Kaccayana's Pali grammar gives a series of number names increasing by multiples of 10 million.

Numerical symbolisation

In the *Atharva-Veda* there is mention of "written amount" which suggests that writing was prevalent in vedic times. In Mohenjo Daro inscriptions we find certain numbers written in vertical strokes probably symbolising numerals from one to thirteen (Fig.5). A similar type of arrangement is found in *Kharosthi lipi* known in India from first century BC to third century AD. But this script seems to have come to India from outside as it is written from right to left. More developed forms of the numerals are found in the various inscriptions found in India. The Brahmi numerals, which we find on the rock edicts of Ashok (third century BC) and other inscriptions distributed all over India, seem to be a purely Indian invention. The decimal system was known to Aryabhat and Brahmgupta long before it became known to Arabs and the west.

In the Hindu literature the words used for zero are *bindo* and *shunya*. As early as 200 BC, in his *Chandah-sutra* Pingala used the zero symbol in metrics. In Bakhshali manuscript we find use of zero as dots in various calculations. The Hindu mathematicians defined zero in their arithmetic as the result of operation $A-A=0$. This is found in Brahmgupta's work and all later works. It is directly used in addition, subtraction and multiplication.

In Brahmgupta's work zero has also been used in algebra.

The methods of addition, subtraction and multiplication were known to the ancient Hindus. The numbers of 139 and 27 were expressed as $40+100-1$ and 3×9 respectively. In geometry they knew how to find the area of a triangle, a trapezium and a circle and calculated the value of π at 3.1416. They also drew up the tables of sines. In the Hindu algebra, origin of which goes back to the age of Sulba (800 BC-500 BC) and Brahmins (1000 BC), numerous types of equations, both simple and complex, have been formulated and solved. Aryabhat, Brahmgupta and Bhaskara propounded the rules for finding permutations and combinations.

Conclusion

The foregoing is a brief review of how different channels of science developed and flourished in India and placed this country at the top of world civilizations. The history of Gupta period is a glittering example of the rise of Hindu science. With the turn in time, the external aggressions and internal quarrels diverted the attention of the Hindus from these problems to the question of survival. Hindu science disappeared from life to remain only in the pages of history.

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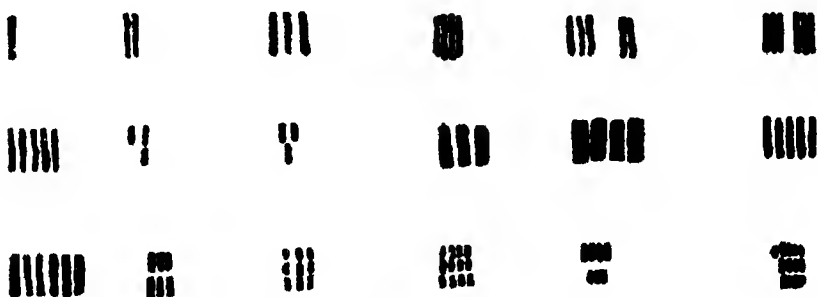


Fig.5. Numeral notation

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MASS OF THE NEUTRINO

The question of neutrino mass has important implications not only for particle physics theories but also for astrophysics and cosmology

PROBIR ROY
ORUGANTI SHANKER

RECENT evidence that the neutrino may have a nonzero mass has led to some excitement in particle physics. In this article we explain why a nonzero mass excites such interest, and also discuss some recent theoretical work stemming from the experimental results

The existence of a new particle, the neutrino, was postulated in the early thirties to explain a puzzle in radioactive B-decay. In these decays an electron or positron is emitted, and the nucleus changes its atomic number to maintain electric charge conservation. Originally, the final state of the decay process was thought to consist of two particles: the emitted β -particle and the final nucleus. The conservation of energy and momentum then implies that the β -particle must be monoenergetic. Its energy equals the difference in energy between the initial and final nuclei. However, experimentally it was found that the β -particles were emitted with a continuous range of energies! Thus, the laws of conservation of energy and momentum seemed to be violated, and some physicists including Niels Bohr even claimed that such was the case. It was left to Wolfgang Pauli to hit upon the correct explanation, without giving up the fundamental conservation laws.

In a letter dated 4 December 1930 to participants in a conference on radioactivity, Pauli mentioned that if a very light, neutral, weakly interacting particle existed and was emitted along with the β -particle, then one could explain the continuous energy spectrum. Later, Enrico Fermi suggested the name 'neutrino' for Pauli's particle in order to distinguish it from the neutron. The neutrino and its cor-

responding antiparticle, called the antineutrino, are usually denoted by the symbols ν and $\bar{\nu}$ respectively. Thus all nuclear B-decay reactions can be designated as

$$(A, Z+1) \rightarrow (A, Z) + e^+ + \bar{\nu} \quad \dots (1a)$$

$$(A, Z-1) \rightarrow (A, Z) + e^- + \nu \quad \dots (1b)$$

with (A, Z) being a nucleus of mass number A and atomic number Z . The postulated particle was actually observed in 1956 through the inverse reaction $\bar{\nu} (A, Z) \rightarrow (A, Z-1) + e^+$ by Cowan and Reines who placed detectors near a nuclear reactor (which is one of the most intense sources of this elusive weakly interacting particle).

While it was recognised right from the beginning that the mass of the neutrino must be very small, the physics community including famous physicists was divided into two camps. One camp (including Weyl, Landau, Feynman, ...) felt that the neutrino must be massless while the other camp (including Majorana, Gell-Mann, Marshak, ...) believed that a small nonzero mass for the neutrino was likely. Pauli himself maintained an ambivalent attitude to the question. It is worth noting that, unlike the photon whose being massless is required by electromagnetic gauge invariance, the masslessness of the neutrino is not demanded by such a fundamental principle.

The experimental determination of the neutrino mass involves the measurement of the shape of the β -spectrum which is sensitive to the neutrino mass near the end-point. Fig. 1 shows the square root of the electron spectrum $N(E_e)$ (divided by the electron energy E_e) plotted versus E_e . The reason for plotting this function of $N(E_e)$, rather than $N(E_e)$ itself,

is that one gets a straight line (called the Kurie plot) when the mass of the neutrino m_ν is zero. For small values of m_ν the straight line shape is modified near the end-point and it curves inward as shown in the figure. The measurement of this amount of curvature can be used to determine the neutrino mass. To get good results one needs to measure the electron energy very accurately.

Lubimov's group at the Institute of Theoretical and Experimental Physics in Moscow, USSR, have done this experiment using the tritium β -decay ${}^3\text{H} \rightarrow {}^3\text{He} + e + \bar{\nu}$. They got the result $M_\nu \geq 20 \text{ eV}$. They measured the β -spectrum from the decay of tritium bound in a valine molecule. To extract the neutrino mass from the shape of the spectrum, one therefore has to use some molecular physics calculations. Since the question of the neutrino mass is so important, experimental groups in Los Alamos and Livermore in America are performing experiments with an atomic tritium beam and in frozen atomic tritium respectively, to make the result less dependent on theoretical inputs.

A glance at Table 1 (which shows all the presently known fundamental particles and their masses) indicates

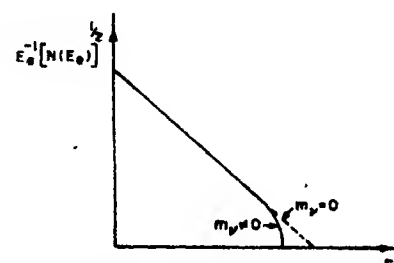


Fig.1. Shape of electron energy spectrum in radioactive β -decay (Kurie Plot)

Table 1. The presently known elementary fermions

		Family one		Family two		Family three	
		Particle	Mass	Particle	Mass	Particle	Mass
Leptons	Q=0	ν_e	20 eV - 55 eV	ν_μ	< 0.5 MeV	ν_τ	143 MeV
	Q=-1	e	0.5 MeV	μ	106 MeV	τ	1800 MeV
Quarks	Q=2/3	u	5 MeV	c	2000 MeV	t	(30-50)×1000 MeV
	Q=-1/3	d	9 MeV	s	140 MeV	b	5000 MeV

why this result is interesting. One sees that the neutrinos, if massive, have to be much lighter than the charged particles (at least a million times lighter). This is a rather striking fact, and seems to indicate something about the structure of the physical theory. In the weak interaction theory of Glashow, Weinberg and Salam (which fetched them Nobel Prize in 1979) this fact was explained as detailed below. All relativistic charged spin half particle wave functions come with four components each (i.e., particle with spin up, particle with spin down, antiparticle with spin up and antiparticle with spin down). For a relativistic particle to have a mass according to the theory of Dirac, all these four components are needed. The GWS theory assumes that two of these four components are absent from the neutrino (i.e., it assumes that a neutrino always has its spin aligned opposite to its direction of motion, and the component with spin aligned in the direction of motion is absent, and vice versa for the antineutrino). Then the neutrino cannot get a mass.

While the GWS theory can thus explain an exactly massless neutrino, a small nonzero mass necessarily implies the need for some modification or extension of this standard explanation. Hence the experimental result of Lubimov's group, if true, shows that one has not understood everything in this problem, and is a pointer towards new directions that need to be explored. Even before Lubimov's work, people had been investigating possible extensions of the GWS theory. In these extensions the neutrino can pick up a nonzero

mass. The smallness of the neutrino mass is related to the heavy mass scale characterizing new physics. Before describing these ideas one must explain the concept of Majorana and Dirac particles. A Majorana particle is a fermion (spin half particle) which is its own antiparticle (analogous to the neutral Bose particle π^0). It comes in two states (components), i.e., spin pointing along the direction of motion, and spin pointing opposite to the direction of motion. Since particles and antiparticles have opposite electric charges, a Majorana particle necessarily carries zero charge (the only number which is equal to its negative is zero!). A Dirac particle is a fermion in which the particle and antiparticle states are distinct. Because of this, a Dirac particle has double the number of states that a Majorana particle has.

When one has several Majorana particles, say n of them, one has to diagonalise an $n \times n$ matrix (mass-matrix) to find the physical masses of the particles. The form of this matrix depends on the details of the theory. The origin of this matrix lies in Quantum Field Theory and its description is beyond the scope of this article. We will just take the matrix as given, for each of the extensions of the GWS theory that we will consider. When one has a Dirac particle, one can form two orthogonal self-conjugate combinations of the particle and antiparticle states. Thus, one can view a Dirac particle as being made up of two degenerate (meaning: equal in mass) Majorana particles.

Now let us look at the neutrino mass-matrices that arise in extensions of the standard explanation and

see how these mass-matrices naturally relate the smallness of the neutrino mass to the heavy scales that characterize new physics. In these extensions one often puts back the two neutrino states, mentioned earlier, that were excluded in the GWS theory. Since it was the exclusion of these states that led to the neutrino being massless in the latter, the neutrino now picks up a Dirac mass m of the order of the charged fermion masses (by analogy with charged particles). Since a Dirac particle can be considered to be a combination of two Majorana particles with equal masses, it can be described by a 2×2 matrix whose form is

$$\begin{bmatrix} 0 & m \\ m & 0 \end{bmatrix}$$

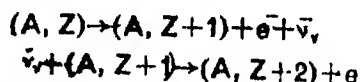
The eigenvalues of this matrix are m and $-m$. The negative sign need not concern us in this article, we just note that the physical masses are given by the absolute values of the eigenvalues. Now, in the extensions of the standard model (for example, Grand Unified Theories) there is a new heavy mass scale M which is used to suppress the neutrino mass to the observed level. The mass matrix now becomes

$$\begin{bmatrix} 0 & m \\ m & M \end{bmatrix}$$

describing two nondegenerate Majorana particles with masses M and m^2/M (for $M \ll m$). Thus the Dirac particle is replaced by two nondegenerate Majorana particles. The heavy Majorana particle with mass M corresponds to the two neutrino states absent from the GWS theory. The usual, observed neutrino has the

mass m^2/M and corresponds to the states present in the standard explanation. Thus, the smallness of m_ν compared to charged fermion masses is because of the small factor m/M . We note that the extensions of the standard explanation which use this suppression trick (i.e., most of the extensions existing in the literature) predict that neutrinos are Majorana particles.

What does experiment tell us about the Majorana or Dirac nature of the neutrino? The Russian experiment gives us the mass of the neutrino, but does not tell us whether it is a Majorana or a Dirac particle. Information on this question comes from experiments searching for the neutrinoless double-beta-decays $(A, Z) \rightarrow (A, Z+2) + e^- + e^-$ or $(A, Z) \rightarrow (A, Z-2) + e^+ + e^+$. These processes can occur only if the neutrino is a Majorana particle. To understand the reason one can conceive the process as occurring in two steps. Let us consider the first reaction. We may imagine it as occurring in two steps through a virtual antineutrino $\bar{\nu}$.



The first step is just the usual β decay of Eq. 1b. The second step would be the inverse β decay reaction to Eq. 1b, if one had written ν instead of $\bar{\nu}$. If one is dealing with Dirac neutrinos, then ν and $\bar{\nu}$ are distinct, the second step does not occur, and the no-neutrino double- β -decay is prohibited. If the neutrinos are Majorana particles, then the second reaction is allowed since there is no distinction between ν and $\bar{\nu}$. Thus, in this case one can have the no-neutrino $\beta\beta$ decay process; its rate turns out to be proportional to the square of the neutrino mass. If one takes the neutrino mass value from Lubimov's group one can use nuclear physics to calculate the expected rate. Experiments looking for this process do not find it, though they are sensitive to the expected rate. The neutrino seems to be a Dirac particle, in contrast to theoretical expectations!

Thus one needs some new idea to explain naturally the occurrence of a Dirac neutrino with a very small mass.

One new idea was provided by the present authors, who were motivated by Grand Unified Theories with supersymmetry. In supersymmetric Grand Unified Theories one needs extra fermions and bosons, and also a new mass scale related to supersymmetry which is intermediate between the charged fermion mass scale and the grand unification mass scale. Our work uses two more fermions in addition to the neutrinos used in the Grand Unified Theories discussed above. Thus, one gets at 4×4 mass matrix. The form of the matrix is

$$\begin{pmatrix} 0 & 0 & A & 0 \\ 0 & 0 & B & C \\ A & B & 0 & 0 \\ 0 & C & 0 & 0 \end{pmatrix}$$

where A is of the order of the charged fermion mass scale, while B and C are related to the Grand Unification and supersymmetry scales respectively. According to supersymmetric grand unified theories C and B are $\sim 10^{19}$ and 10^{16} gigaelectronvolts respectively. Thus, $A \ll B$ eigenvalues of the above matrix can easily be seen to be $+B$, $-B$, $+AC/B$, $-AC/B$. The occurrence of the eigenvalues in pairs with equal magnitude and opposite signs implies that the four Majorana particles combine to form two Dirac particles. One of the Dirac particles has a large mass B and the other which is the neutrino observed in the laboratory has a mass AC/B . The observed neutrino thus is suppressed in mass relative to the charged fermion mass by the small factor $C/B \sim 10^{-6}$. It is also predicted to be a Dirac particle. Thus this scheme is able to explain both the tritium β -decay experiment and the lack of observation of no-neutrino double- β -decay simultaneously.

We will conclude with a brief discussion of some issues related to neutrino masses. As seen from Table 1, there are three types of neutrinos corresponding to the three families in which the observed fundamental particles group themselves. The above neutrino mass suppression scheme can be easily extended to the case of three neutrinos (here A , B and C themselves become 3×3

matrices). Theoretically, one expects that neutrinos of one type produced in the laboratory will change over into neutrinos of another type periodically as functions of time C (this phenomenon is called neutrino oscillation). Such a transition has not yet been observed, but this may be because the experimental sensitivity is not sufficient. Also, nonzero neutrino masses have important implications for cosmology and astrophysics. For example, cosmological models predict that the universe is permeated by a sea of neutrinos. If the neutrinos have a finite mass, then this sea of neutrinos would alter the rate at which the universe is expanding, due to gravitational attraction. The calculations based on the observed expansion rate of the universe give an upper bound on the sum of the masses of all stable neutrinos. However, theoretical considerations of the type alluded to earlier imply that the neutrinos of the higher families, ν_μ and ν_τ are substantially heavier. Thus to avoid conflict the ν_μ and ν_τ may have to be unstable. In the scheme considered by the authors the ν_μ and ν_τ are expected to decay to ν_e along with the emission of a massless (or almost massless) scalar particle called the goldstone (or pseudogoldstone) boson. Although no detailed theory of such emissions has yet been worked out, qualitative considerations suggest a viable mechanism.

In conclusion, we have seen that the question of neutrino masses has very important implications for the structure of the fundamental particle physics theories as well as for astrophysics and cosmology. It is very important to pursue this question further both theoretically and experimentally.

Further reading

1. Barrow, J.D. and Silk, J., *Nature* (News and Views), 308 (1984), 13.
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(Continued on page 664)

DECEMBER 1984

PITUITARY HORMONES IN FISH BREEDING

NIRMAL K. THAKUR

Extracts of fish pituitary gland can be used for induced breeding of economically valuable fish species

FISH breeding by pituitary hormone injection, also referred to as hypophysation, is an effective and a dependable way of obtaining pure seed of cultivable fishes and is practised today on a fairly extensive scale in India as well as scores of other countries in the world. The hypophysation of fishes provides an outstanding example of the successful application of a laboratory technique to the solution of a big practical problem. Although fish breeding through hypophysation is well established as a technique now, scientists are still continuing their research on it to counteract several field problems in order to make the know-how more and more simple and acceptable for its extension in rural areas.

Historical background

The present day concept of the role of pituitary in the reproduction of vertebrates is reported to have originated from the experiments of S. Aschheim and B. Zondek in 1927 when they found that pituitary implants accelerated the sexual development of female mice. Three years later, in 1930, B.A. Houssay of Argentina performed first such experiment on a fish. He injected a small viviparous catfish (*Crestedodon decemmaculatus*) with extracts prepared from freshly removed pituitary glands from another species of fish (*Prochilodus platensis*) bringing about the premature birth of developing young. Getting clue from Houssay's work, R. von

Ihring, Director of a federal fish cultural establishment in Brazil, started working on the problem. By 1934, a successful technique could be worked out in which certain Brazilian pond fishes were made to spawn by injecting them with a suspension of fresh pituitary glands collected from other less valuable species of fishes. The Brazilians, thus, were the first to use the technique of fish breeding successfully through hypophysation. The Russians were the next to introduce hormone treatment in fish breeding. Although scientists in USSR had started making such attempts at induced breeding in 1932, it was not until five years later that Gerbil'skii finally succeeded in inducing a significant number of Sturgeons (*Acipenser stellatus*) to produce mature eggs and milt by injecting them intracranially with fresh pituitaries of the same species. At present not only the Sturgeons but several other important species of food fishes in USSR are being increasingly induced bred for culture by adopting the method of hypophysation.

India is the third country in the world to make the technique an integral part of its piscicultural programmes. The first attempt at hypophysation in India was made by Hamid Khan in 1937 when he tried, albeit unsuccessfully, to induce spawning in *Cirrhinus mrigala* by the injection of mammalian pituitary gland. Next attempt in this direction was made by A. Hussain in 1945 who administered certain hormones (80-

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120RU Prolan and Antuitrin-S) into female *Labeo rohita* and *Cirrhinus mrigala*. The injection did help in making them easy to strip but the eggs could not be fertilized. After this, for a period of about ten years, no further attempts were made in this direction. It was in 1955 that Hira Lal Chaudhuri succeeded in inducing spawning in *Esomus danricus* by intraperitoneal injection of the extract prepared from the pituitary gland of *Catla catla* at the Pond Culture Division of the Central Inland Fisheries Research Sub-station, Cuttack (Orissa). Soon, he also succeeded in breeding *Pseudotropius atherinoides* by administering extract of pituitary gland from *Cirrhinus reba*. Almost during the same period, at the Zoological Laboratories of Mysore University, emerged another team of scientists, L.S. Ramaswamy and B.I. Sundararaj, who achieved success in induced breeding in air-breathing catfishes, *Heteropneustes fossilis* and *Clarias batrachus*, in 1955 and 1956 respectively.

The first success in induced breeding of Indian major carps (*Labeo rohita* and *Cirrhinus mrigala*) and medium sized carps (*Labeo bata*, *Cirrhinus reba* and *Puntius sarana*) through hypophysation was achieved in 1957 by Hira Lal Chaudhuri and K.H. Ali-kunhi at the CIFR Sub-station, Cuttack. For breeding *Catla catla*, several attempts were made during the years 1955 to 1958 at Cuttack, but successful spawning was achieved only in May 1959 at Joysagar, Assam. Not



Fig.1. Pituitary hormone injection is being given intra-muscularly to a female *Labeo rohita*

only the major carps but several other species of cultivable fishes including the exotic carps and even certain brackish water varieties are bred through hypophysation and the technique forms a regular part of fish culture activities in many parts of India now.

What is pituitary gland?

The pituitary gland, also referred to as hypophysis in technical expression, is one of the most important glands of the endocrine system having direct bearing on the reproductive processes in vertebrates. It lies in a bony depression called the sella turcica at the base of the brain. It secretes the gonadotropic hormones which consist of two distinct substances. The identity of these gonadotropic hormones was first established by the use of female rats as test animals. The two hormones were, therefore, named with reference to their effects on ovary, the follicle stimulating hormone (abbreviated as FSH) and the luteinizing hormone (or LH). Later, it was shown that both these hormones were also secreted by pituitary glands of males but no effort has since been made to rename FSH when its effect in males is discussed. Both these hormones are secreted all round the year, but the proportion in which they are secreted is directly correlated with the cycle of gonadal maturity. The FSH causes the growth

and maturation of ovarian follicle in females and spermatogenesis in the testes of males while LH helps in transforming the ovarian follicles into corpora lutea in females and promoting the production of testosterone in males. These hormones are not species specific, i.e., a hormone obtained from one species is capable of stimulating the gonads of another. However, there is great variability in its effectiveness in different species. Experiments conducted on induced breeding of fishes have clearly shown the relative effectiveness of fish pituitary extracts over mammalian pituitary hormones, sex hormones and various steroids. This is the reason why fish pituitary is being extensively used today in fish breeding work all over the world.

In fishes, the pituitary gland is formed in the form of a compact small mass of creamy-whitish colour lying on the ventral side of the brain immediately behind the optic chiasma on the floor of the brain box. In shape, it may be spherical, cylindrical, ovoid or conical depending upon the species. The size and weight vary according to the size and weight of the fish. For example, a *Labeo rohita* in the weight range of one to two kg has a pituitary gland of 6.6 mg average weight, in two to three kg 10.3 mg, in three to four kg 15.2 mg, four to five kg 18.6 mg and likewise. The gland usually remains attached to the brain by a stalk (infundibular stalk) which may be short,

slender or moderately long. Sometimes, a distinct stalk may be totally missing. Glands having distinct stalk are classified as leptobasic type as in Cyprinidae and without a distinct stalk as platybasic type as in Nandidae, Channidae, etc.

Morphologically, the pituitary gland in fishes is composed of two different parts: the glandular part, the adenohypophysis and the nervous part, the neurohypophysis. It is actually the adenohypophysis which plays the key role in controlling gonadal functions. The adenohypophysis, in fact, is the largest part of the gland and is composed of three more or less distinctly distinguishable lobes, viz., (i) anterior glandular lobe or rostral pars distalis, (ii) middle glandular lobe or proximal pars distalis and (iii) posterior glandular lobe or pars intermedia. Of the three, the middle glandular lobe or proximal pars distalis is the most important. It secretes most of these hormones. Thyrotropins, somatotropins and gonadotropins are the main secretory hormones of this lobe. The thyrotropins help in the formation of thyroxine which controls the growth and activity of thyroid. The somatotropins stimulate cellular growth causing increase in body size. The gonadotropins, which are secreted by certain basophilic cells in the ventral portion of the lobe, play an important role in the development of gonads. The fish gonadotropins, in fact, have not been studied so much in detail as gonadotropins in mammals. It is believed that like mammalian pituitary, fish pituitary also contains both FSH-like and LH-like gonadotropins. There are, however, different views regarding content and release of FSH and LH from fish pituitaries. In some fishes, two gonadotropins have been described while in others only one type has been identified. Several attempts have been made in the recent past to isolate and purify the gonadotropic hormones from the teleostean pituitary glands through chemical fractionation. Three different fractions could be obtained in the process of which the second fraction has been reported to be effective in inducing ovulation and spawning in fishes.

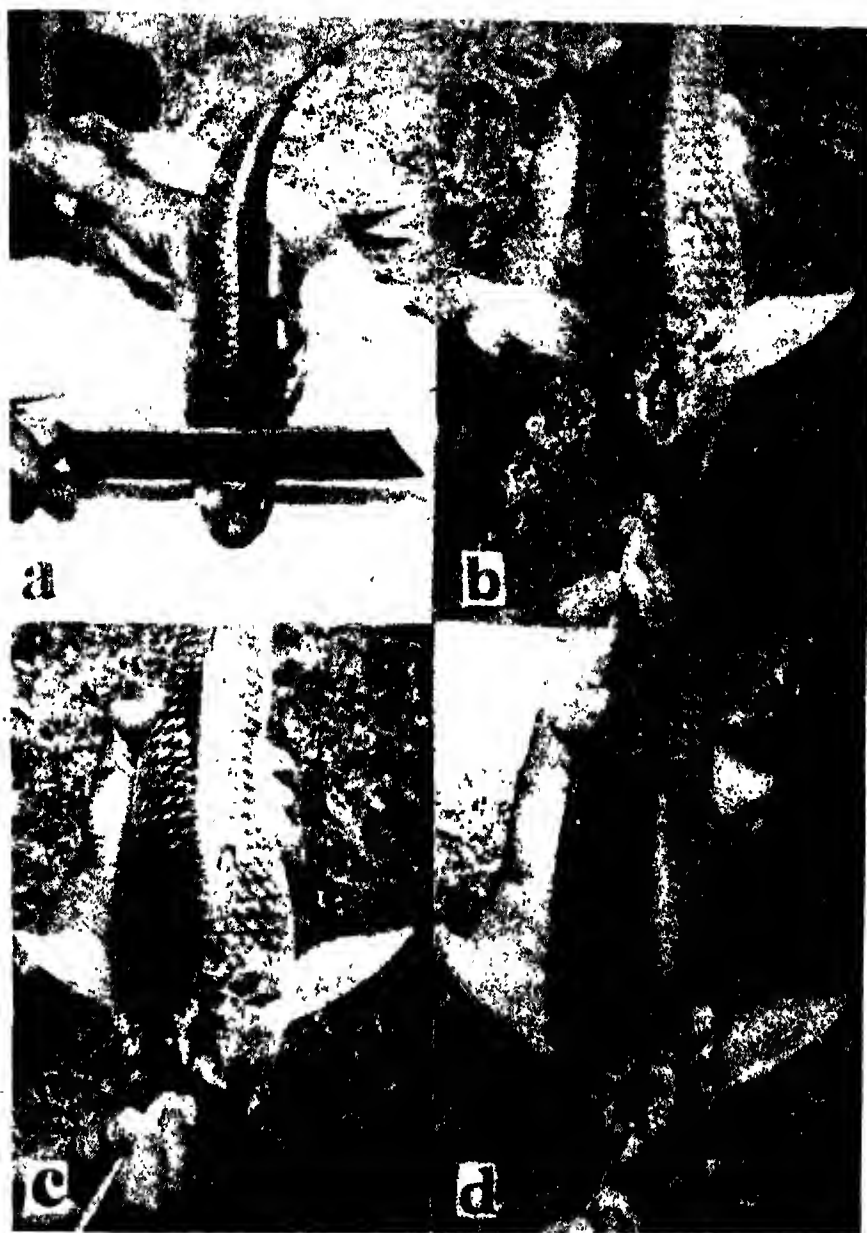


Fig.2. Removal of pituitary gland from fish-head: (a) the scalp of the fish is being chopped off by an oblique stroke of a butcher's knife, (b) the brain has been exposed after cleaning the grey matter and fatty substances from the cut portion of the scalp, (c) the brain has been lifted out to expose the floor of the brain box, (d) the gland is being removed

Collection of pituitary glands

Pituitary glands are collected from the ripe gravid fish of both sexes either belonging to the same species as the recipient or a closely related one. Immature and spent fishes are generally avoided. The most appropriate time for collection of glands from the Indian major carps is just prior to or during the breeding season. Since common carp (*Cyprinus carpio*) is a perennial breeder, its

mature individuals can be obtained almost all round the year for the collection of glands. The glands are usually preferred to be collected from freshly killed fishes but those collected from ice-preserved specimens are also used.

Several techniques are adopted for the collection of pituitary glands in different countries. In India, the commonly adopted technique of gland collection is by chopping off the scalp of the fish skull by an oblique stroke

of a butcher's knife. After the scalp is removed, the grey matter and fatty substances lying over the brain are gently cleaned with a piece of cotton. The brain thus exposed is carefully lifted out by detaching it from the nerves. In the majority of the Cyprinids, when brain is lifted, the gland is left behind on the floor of the brain box. The membrane (dura mater) covering the gland is then cautiously removed using a fine needle and forceps. The exposed gland is then picked up intact without causing any damage to it because damaged and broken glands result in loss of potency.

Glands are also collected through foramen magnum. It is, in fact, a much easier method of gland removal which is commonly practised by the professionals for mass-scale collection in crowded and noisy fish markets. In this method of gland collection, the fish is required to be essentially beheaded. In markets, glands are collected from fish-heads that are already cut by retailers. In the cut fish-heads, the foramen can be clearly seen from behind holding grey matter and fatty substances in it. The brain lies on the ventral side of the foramen. For taking out the gland, the grey matter and fatty substances are first removed by inserting the blunt

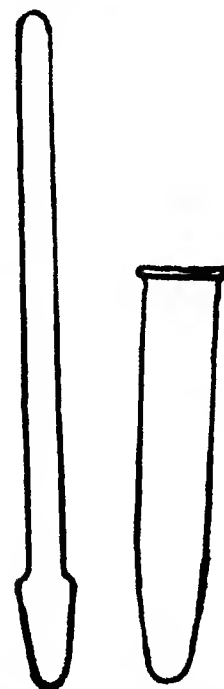


Fig.3. A tissue homogenizer

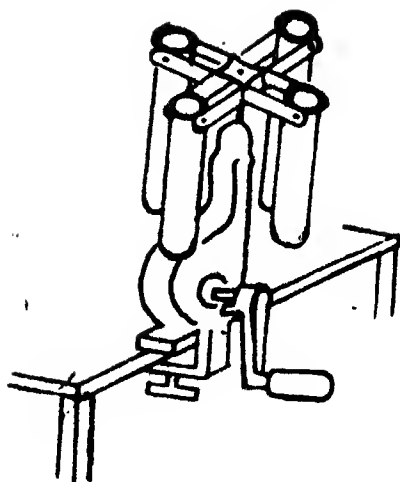


Fig.4. A hand centrifuge machine

end of the forceps into the foramen and pulling out the entire matter without disturbing the brain. The brain is then lifted up carefully and pushed forward or is pulled out of the hole. The gland lying at the floor of the brain box is then picked up using a pair of fine tweezers. An experienced worker easily manages to collect about 50 to 60 glands in one hour by adopting this technique of collection.

Preservation of pituitary glands

If the collected glands are not meant for use then and there, they must be preserved at once or else due to their glyco- or muco-protein nature they are liable to immediate enzymic action. The glands after collection are immediately put in absolute alcohol for defatting and dehydration. After 24 hours, the glands are washed with absolute alcohol and kept again in fresh absolute alcohol contained in dark coloured bottles and stored either at room temperature or in a refrigerator. Occasional changing of alcohol helps in keeping the glands in good condition for longer periods. Preservation of glands in absolute alcohol is, in fact, more convenient because it does not essentially require a refrigerator for subsequent storage and is, therefore, most suited particularly to the poor farmers in a country like India.

Acetone also is a good preservative. In this method, soon after collection, glands are kept in fresh acetone or in dry ice-chilled acetone inside a

refrigerator (10°C) for 36 to 48 hours. During this period, the acetone is changed two to three times at about 8 to 12 hours intervals for proper defatting and dehydration. The glands are then kept out of acetone, put on a filter paper and allowed to dry at room temperature for one hour. They are then stored in a refrigerator at 10°C , preferably in a desiccator charged with calcium chloride or any other drying agents. The preservation of glands in acetone is largely practised in USSR and the USA.

Preparation of pituitary extract

At the time of injection, the required quantity of glands is taken out and kept on a filter paper for alcohol to evaporate. The glands are then macerated in a tissue homogenizer by adding a measured quantity of distilled water. The concentration of the extract is usually kept in the range of 1 mg to 4 mg of gland per 0.1 ml of distilled water. After homogenization, the suspension is poured into a centrifuge tube. While pouring, the homogenizer should be thoroughly shaken so that the settled particles of the gland at the bottom of the tube get mixed up with the solution and come into the centrifuge tube. The extract in the tube is next centrifuged and the

supernatant fluid (the clear fluid containing the hormones) is drawn into a hypodermic syringe for injection.

The pituitary extract can also be prepared in bulk and preserved in glycerine (1 part of extract: 2 parts of glycerine) before the fish breeding season so that botheration of preparing extract every time before injection is avoided. The stock extract should always be stored in a refrigerator or in ice.

Technique of breeding

The induced breeding operation of the Indian major carps is taken up when regular monsoon sets in, the fishes become fully ripe and water temperature goes down. Females having round, soft and bulging abdomen with swollen reddish vent and males with freely oozing milt are selected for breeding. A male breeder can also be easily distinguished by roughness on the dorsal surface of its pectoral fins. In usual practice, the female alone is injected with an initial stimulating dose of 2 mg/kg to 3 mg/kg weight followed by a second dose of 5 mg/kg to 8 mg/kg weight after a lapse of six hours. Two males against each female make a breeding set. To make a good matching set, the

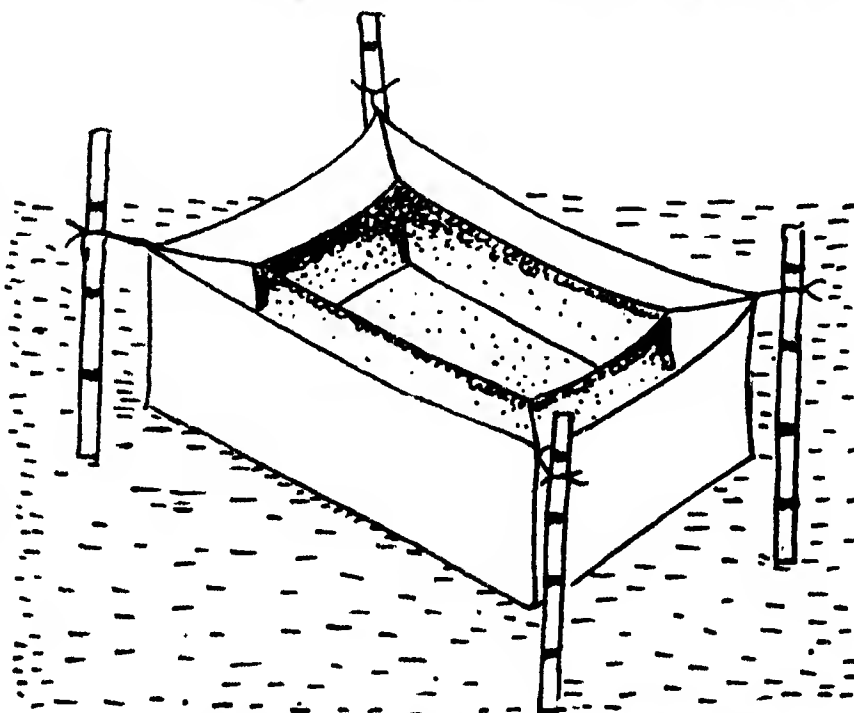


Fig.5. A sketch of hatching hapa showing the arrangement of outer and inner hapas

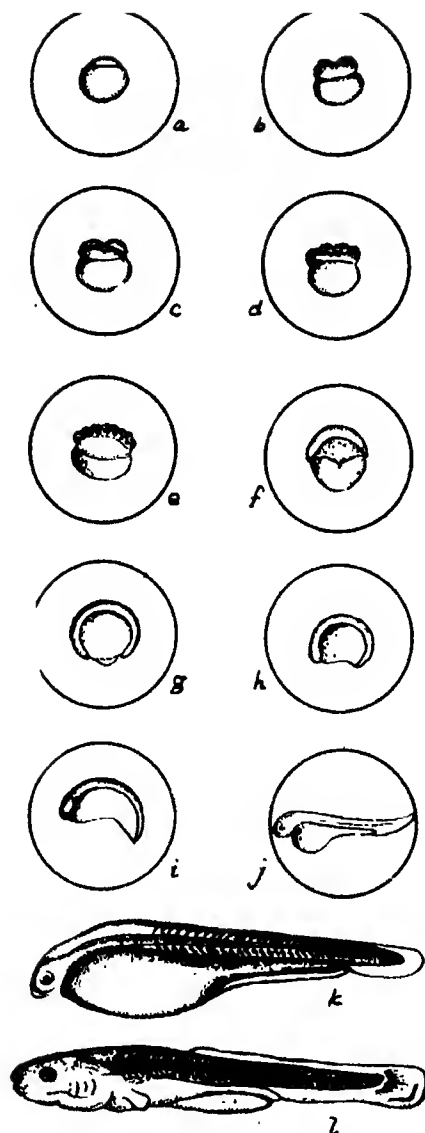


Fig. 8. Diagrammatic representation of the developing eggs and larvae of an Indian major carp. (a) fertilized egg showing the formation of blastodisc, (b) two-celled stage, (c) four-celled stage, (d) eight-celled stage, (e) 16-celled stage, (f) morula stage, (g) yolk-plug stage, (h) embryo with discernible head and tail ends, (i) 'comma-shaped' stage of the embryo, (j) embryo in an advanced stage of development, (k) just hatched out baby and (l) four-day old baby fish

weight of the males together should be equal to or a little more than the female. Both the males are given only a single dose each of 2 mg/kg to 3 mg/kg weight at the time of second injection to the female. Slight alterations in doses may be made depending upon the condition of maturity of breeders and the prevailing environmental factors.

While intra-cranial injections are given in USSR and intra-peritoneal in Japan and USA, in India, intramuscular injection is the most common practice. Injections are usually given at the caudal peduncle or shoulder region near the base of the dorsal fin. While giving injections to the carps, the needle is inserted under a scale keeping it first parallel to the body of the fish and then pierced into the muscle at an angle. There is no hard and fast rule regarding the time of injection. Injections can be given at any time of the day and night. But since low temperature is helpful and night time remains comparatively quieter, the injections are generally given in the late afternoon or evening hours with timings so adjusted that the fish is able to use the quietitude of the night for undisturbed spawning.

After the injection, the breeders are released immediately inside the breeding hapa. A breeding hapa is generally made of fine cloth in the standard sizes of 3.5m×1.5m×1.0m for large breeders and 2.5m×1.2m×1.0m for breeders weighing less than 3 kg. All the sides of the breeding hapa are stitched and closed excepting a portion at the top for introducing the breeders inside. Generally, one set of breeders is introduced into each breeding hapa but sometimes in order to save on pituitary material, 'community breeding' is also tried by reducing the number of male breeders. After the release of the fish, the opening of the hapa is securely closed so that breeders may not jump out and escape. Instead of hapas, cement cisterns or plastic pools as big as hapas can also be used for breeding. A 30 cm to 35 cm height of water has to be maintained in the cisterns/pools, preferably with circulation. Tap water or well water may be used, but chlorinated water has to be avoided.

Spawning normally occurs within 3 to 6 hours after the second injection. Soon after fertilization, the eggs swell up considerably owing to absorption of water. Fertilized eggs of major carps appear like shining glass beads of crystal clear transparency while the unfertilized ones look opaque and whitish. The size of eggs from the same species of different breeders varies considerably. Fully swollen

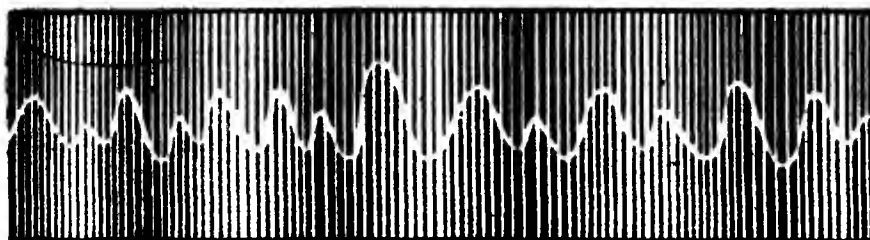
eggs of the Indian major carps measure 2.5 mm to 6.5 mm in diameter, the largest being that of *Catla catla* and the smallest, of *Labeo rohita*. The carp eggs are non-floating and non-adhesive type. The yolk possesses no oil globule. The Indian major carps have a profuse egg laying capacity. Their per kg fecundity, on an average, is 3.1 lakh in *Labeo rohita*, 1.3 lakh in *Catla catla* and 1.5 lakh in *Cirrhinus mrigala*.

The developing eggs are retained in breeding hapa undisturbed for a period of at least 4 to 5 hours after spawning to allow the eggs to get properly water-hardened. After this, the eggs are collected from the hapa using a mug and poured into a bucket with a small amount of water. The breeders are then taken out and weighed to find out the difference before and after spawning. This gives an idea of the quantity of the eggs laid. The total volume and number of eggs laid can be easily calculated from the known volume and number of eggs of the sample mug. Percentage of fertilized eggs is also assessed accordingly by making random samplings.

Technique of hatching the eggs

The eggs collected from breeding hapas are transferred into the hatching hapas. A hatching hapa consists of two separate pieces of hapas, the outer hapa and the inner hapa. The inner hapa is smaller in size and can be fitted inside the outer hapa. The outer hapa is made of thin cloth in the standard size of 2m×1m×1m while the inner hapa is made of round meshed mosquito net cloth in the dimension of 1.75m×0.75m×0.5m. All the corners of the outer and inner hapas are provided with loops and ropes to facilitate installation. About 75,000 to 1,00,000 eggs are uniformly spread inside each inner hapa. The eggs hatch out in 14 to 20 hours at a temperature range of 24°C to 31°C. The period of incubation, in fact, is inversely proportional to the temperature, i.e., lower the temperature longer the period of incubation and vice versa. After hatching, the hatchlings escape into the outer hapa through the meshes of the inner one. The inner hapa containing the egg

(Continued on page 664)



SCIENCE SPECTRUM

Computer and brain diseases

METHODS of medical diagnostics to monitor functions of human body are becoming sophisticated day-by-day. The newly devised Gamma Camera and Computer give not only the anatomical details but also the actual functioning of organs for proper diagnosis and systematic therapy. An anatomical and physiological view of a patient's interior can also be had. However, the procedures are simple, require just an injection, and the information gathered is so valuable that it is worth the money spent.

The Gamma Camera was invented in 1958 by an American Angel at the University of California. It was commercialised in 1962-63, though it is yet not manufactured in India. The Bhabha Atomic Research Centre (BARC) made a simple scanning device called the 'Rectilinear Scanner' in 1973. The Gamma or Scintillation Camera with attached Computer and Video tape was imported into India in 1972. It was installed at the BARC Radiation Medicine, next to the Tata Memorial Hospital, Bombay. In due course, more sophisticated computers with floppy disc drive systems were installed at Jaslok Hospital & Research Centre, Breach Candy Hospital, Nair Hospital, Bombay; King Edward Medical College Hospital, Bombay; Institute of Nuclear Medicine and Allied Sciences, Delhi; Chaitram Hospital & Research Centre, Indore (M.P.), etc.

In 1973, the time was ripe for a qualitative development of the X-ray machine. An Englishman H. Hounsfield working at the EMI Com-

pany in U.K. began to wonder if a computer could be coupled to an X-ray machine to clear up the mess that goes by the name of diagnostic imaging. As Hounsfield is an engineer, he discussed the subject in detail with some medical doctors. But everybody thought that he was a psychic case. He however continued to work day and night in his small laboratory till his objective was realised and fulfilled. The CAT (Computerised Axial Tomography) took shape. It is the most important single investigation in medical practice recommended today. The device also emits X-rays, but it is so quick and thorough that a scan of

the entire brain, for example, takes just five minutes. The machine examines 32,000 spots in 10 slices of the brain, each slice or cut-taking about 18 seconds. The computer then takes over. It produces the results in form of pictures. The associated calculations and information are ready within 15 minutes. The thoroughness in diagnosis and brief duration of radiation exposure of the patient have virtually placed the device in the category of "Non-invasive technology". Beginning as a diagnostic scan for brain diseases, especially tumors, the machine has since progressed tremendously in the last 10 years. Today the latest development in CAT is total body scanner.

The CAT takes a two dimensional picture of the cross-section of human body. 'TOMOS' means section and 'graphy', of course, is representation. A thin pencil-like beam of X-ray passes through the body section of interest. The radiation after traversing the body is picked up. The computer calculates through fairly straightforward computations the amount of ray absorption by each millimeter of tissue length. The information is then stored, printed and displayed suitably. Very small growths or abnormalities or tumors above 0.75 mm to 1.5 mm in

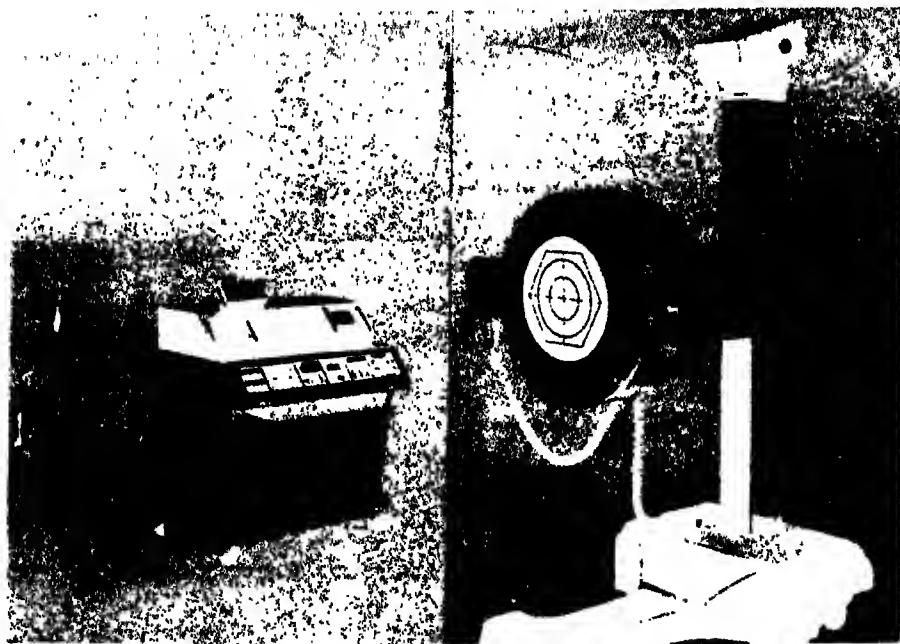


Fig.1. Showing Gamma-camera with detector, used for brain scanning, to detect various brain diseases

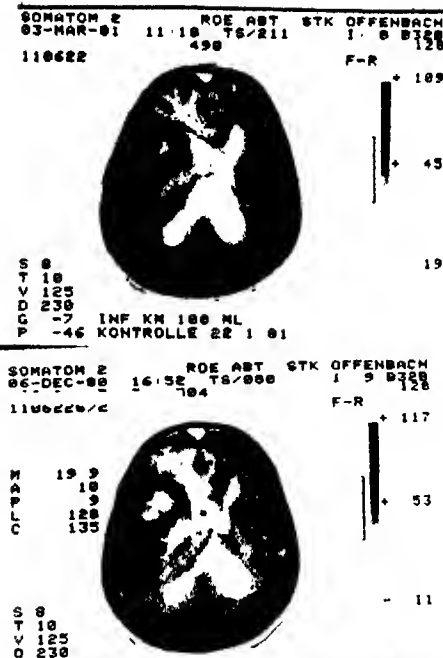


Fig.2. Showing angiomatous tumour by CAT Scan (Computerised Axial Tomography)

size can be detected at an early stage. The image is projected on to a TV screen. The pictures can be enlarged and certain spots can be highlighted for future scrutiny. The CAT, which was manufactured first in 1973, arrived in India in 1977. The first model was installed at the All India Institute of Medical Sciences, New Delhi. A head scanner is now also installed at Chandigarh, Bombay, Madras and SCB Medical College, Cuttack. It can also be used for diagnosing diseases of the eyes and nose. There are only two whole body scanners in the country, one each at the K.J. Hospital, Madras, and Nana-vati Hospital, Bombay. This six ton equipment costs Rs. 1 crore while the head scanner costs Rs 35 lakhs.

A scan costs between Rs 800 and Rs 850. However, one scan accomplishes the equivalent of several X-ray pictures. Here are given the uses of CAT scanner: (i) Head injuries. A CAT, unlike a radionuclide scanner, is sensitive enough to detect acute intracranial bleeding. The bleeding appears more black than normal brain tissue due to high density. However, after several days, haematoma lose their abnormal density and may be difficult to detect by a CAT. In the subacute and chronic situation, the

radionuclide scan is currently the choice. (ii) Cerebral oedema. It is an abnormal condition of the brain tissue where there occurs accumulation of body fluids giving rise to enlargement of the brain cavity. A CAT, unlike radionuclide brain scanner, enables assessment of the size of brain cavity, which is a useful index to the degree of cerebral oedema. (iii) Hydrocephalous. It is an abnormal condition where the head circumference of the child is unusually big. This enlargement of head is usually due to blockage of normal passage of cerebrospinal fluid in the brain cavity. As a result of the blockage, head circumference increases. A CAT allows accurate assessment of the size of brain cavity and changes in brain tissue also. This can be supplemented by radionuclide cisternography which helps in defining abnormal cerebrospinal fluid passage. (iv) Cerebral tumors (Brain tumors). A CAT will detect lesions missed by a radionuclide scanning because (a) the lesions fail to accumulate a detectable amount of radionuclide, (b) the lesions are obscured by overlying or adjacent anatomical structures such as pituitary gland, and (c) the lesions are small and beyond the resolution of the scanner or gamma camera.

A CAT should be used when looking for tumor recurrence following surgery. For technical reasons like edge artefacts which are more common to CAT, the radionuclide scan

may be more useful in the detection of peripherally located intracranial metastasis, e.g., subdural metastasis due to breast cancer; (v) Cerebrovascular disease. Cerebrovascular disease is a condition where there occurs a rupture or blockage in the blood supply to brain tissue leading to death of tissues. In the above diagnosis of cerebrovascular disease a CAT has a specific advantage over radionuclide imaging in that the dead area may be shown in the acute phase as an area of reduced density occurring several hours after the onset of decreased blood flow to the particular region of brain tissues. But it takes ten days for the radionuclide scan to be positive.

Radionuclide Imaging

When the CAT scanner came into existence, every one thought that the gamma ray detector would become obsolete. But it has now been realised that it has its own vital function to perform. While the CAT scanner takes static pictures of an organ, the new gamma ray detector, called "scintigraph" or "gamma ray camera", is capable of a dynamic study. In other words, a scintigraph determines the functions of an organ with respect to time. There are certain abnormalities in the brain such as superior sagittal sinus tumor, angiomatous malformation which cannot be diagnosed by the CAT. A radionu-



Fig.3. Showing aneurysm of middle cerebral artery by Radionuclide Imaging as well as carotid angiography

clide scanner can however diagnose them. A gamma camera consists of two parts, one is the detector part and the other photographic. The detector is circular in shape containing photo-multiplier tubes which receive gamma rays emitted by patient's body due to radio-isotope injection given to him. The photographic part then takes pictures of these attenuated rays. So a series of pictures from different positions of the brain are taken on a film in gamma camera. As the camera is further attached with digital computer a series of multiple views of the brain are projected on to the computer screen. It is stored in the computer memory for further analysis. The computer enables a nuclear physician to study the selective areas of interest of the brain tissue. It also generates curves of both sides of cerebral hemispheres for interpretation.

Usually, there are two types of study of brain-diseases. The first type is dynamic study in which the study of the function of brain tissue is conducted with respect to small time intervals. It is carried out by taking multiple pictures of the brain keeping the time limit of 0.5 seconds per picture for the first 15 seconds. Static or delayed pictures are usually taken after one and half hours of first part of the study. In static pictures, different views of the brain such as anterior, right lateral, left lateral, posterior and vertex views are taken in gamma camera and computer.

The latest development in medical science is N.M.R. (Nuclear Magnetic Resonance). N.M.R. works on the principle of absorption and re-emission of radio frequency electromagnetic energy by certain nuclei placed within strong magnetic field. In this new modality of N.M.R. imaging, no radioisotope injection is given as is done in radionuclide imaging. Here the diseased organ of the patient is usually kept between two strong magnets. As a result, hydrogen atoms present in the body fluids of man act as protons which are deflected by the strong magnetic field. Then the signals are collected together by a sophisticated electronic device which forms N.M.R. images of that particular organ. By this new imaging proce-

dures, metabolic changes in tissue, including intra- and extra-cellular compartments, various inflammatory changes in the body, effect of different drugs given in neurological disorders can be detected.

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Man-made polymers—the engineering materials of future

GROWTH in transportation, communication, packaging and surface coating sectors of economy is a measure of a nation's progress. If there is one single greatest development that has contributed greatly to all the above sectors of economy, it is the development of man-made polymers for use as engineering materials in the above fields. Of the many man-made polymers, the compounds of carbon with hydrogen, fluorine or silicon need particular mention for use as engineering materials in view of their several unique properties. Polymeric materials also referred to as elastomers (rubber-like) or resins are endless molecules stitched together form a large number of monomer units. For example, natural rubber is made up of a large number of recurring identical isoprene units linked into immense chains. The polymers have such unique features as low cost, light weight, high strength and resistance to temperature and corrosive chemicals such as acids, alkalies, solvents, etc., to make them valuable materials for use in several industries such as agriculture, transportation, electronics, packaging, fabrication and paints replacing the conventional materials. We will now consider these materials and their uses in detail.

Synthetic rubbers

Hydrocarbons are compounds of carbon and hydrogen. Rubber is one of the most familiar examples of the hydrocarbon polymers and the discovery of synthetic rubbers has revo-

lutionised transportation industry. For a long time, natural rubber was used for making automobile tyres, hot water bottles, surgeon's gloves, etc. Production of rubber from hevea trees is laborious and properties of natural rubber are not that satisfactory, nor was natural rubber able to meet the demand of the industry. Chemists tried hard to produce isoprene (C_5H_8), the building block of natural rubber, in laboratories and then to polymerise it in a way desirable to produce rubber of satisfactory quality. However, the first man-made rubber was not a polymer of isoprene but was that of a different substance butadiene with a formula of C_4H_6 . A good automobile tyre or tube should not swell in oils and fats, should resist oxidising agents, heat and rapid wear besides being highly impervious to air. The several shortcomings of the natural rubber are greatly overcome by the several varieties of man-made rubber such as the sodium polymerised butadiene or Buna rubber for vehicle tyres and the butyl rubber produced by the joint polymerisation of isobutene and isoprene for tyre tubes. Polyurethane rubbers are used to make foam rubber for upholstery due to their high tensile strength and resistance to aging.

Synthetic plastics

The compounds of carbon and hydrogen are responsible for production of a large number of important materials besides rubber. They are

the plastics. Synthetic plastics like polyethylene, polystyrene, polypropylene, polyvinylchloride, etc., and their applications are quite well-known.

Polystyrene moulding powder is widely used in the manufacture of cassettes, bangles, beads, containers and other domestic goods. During the World War II, a large proportion of styrene was used in making the styrene-butadiene rubber. After the war, the market for plastics grew and polystyrene plastics are one of the most important of this group. Expanded polystyrene or simply called EPS is one of the most widely used insulating material for refrigeration applications since the EPS has a very low density of about 15 kilograms per cubic meter. EPS packing materials are commonly used for packing transistors, mixies, tape recorders and a host of such products. Polyethylene is also largely used in packaging industries. Milk is widely supplied in disposable polythene packets for convenience of consumers. Chemicals are transported in polythene carboys since corrosive liquids like acids are nonreactive to polyethylene.

Polypropylene is also highly resistant to corrosive chemicals and also to temperature upto 130°C . Polypropylene is therefore extensively used for making trays for driers besides its use in making diaphragm valves, ball valves and scrubbers for hazardous gases like HCl , SO_2 , HNO_3 , etc.

Polyvinylchloride (PVC) is another important engineering plastic and is presently used in a variety of applications as a substitute for leather, rubber, paper, glass, cellophane, etc.

PVC protective covers are now being used extensively for covering food grains, cars, scooters, etc., in the open yards to protect them from rain and weather. A large tonnage of PVC is being used in India for the production of pipes and conduits particularly for agricultural and irrigation applications, economical footwear, wires and cables for domestic lighting, rigid films for packaging, blow-moulded containers, etc.

Adhesives and paints

Polyvinylacetate (PVA) is extensively

used in adhesives and paints. The PVA polymers are colourless, transparent and tough and they form films of good heat-sealing properties. The familiar adhesives that are used by furniture makers are based on PVA Acrylates are another important group of hydrocarbon polymers with a major market in surface coatings. Synthetic materials like acrylates have greatly helped in reducing the use of edible oil in the paint industry. The importance of paints as decorative and protective coating films needs no overemphasising. Acrylates are extensively used in textile industry as adhesives, fabric finishes, pigment binders, etc. They are also used as additives to paper pulp to improve tensile strength and folding endurance of paper.

Reinforced plastics and windshields

Polyvinylbutyral is an important material finding widespread use in automobile windshields. A layer of flexible energy absorbing PVB resin is laminated between two sheets of glass in a sandwich manner. These windshields are far safer and it is reported that in America, serious injuries related to windshields in automobile accidents dropped from 15% of all injuries in 1962 to less than 2% in cars manufactured after 1966. Polyester resins are widely used in reinforced plastics whose advantages are too numerous to mention.

Fluorocarbons

Next to hydrocarbons, fluorocarbons constitute an important group of synthesised engineering materials. Few other man-made compounds have such unique properties and uses as fluorocarbons, the compounds of fluorine with carbon. Fluorocarbons are highly unreactive and resistant to heat and practically nothing can destroy them. They neither burn, nor rot nor are affected by inorganic or organic acids, alkalis or solvents.

They have such varying uses as cooling fluids in motors, lubricants, insulators, etc. Polytetrafluoroethylene, or teflon in short, is one of the most important compounds of this group which can withstand heating

upto 300°C . Ietion accounts for about 70% of the fluorine resins used in Japan with a major usage as automobile parts. About thirty parts including piston rings, oil seals, bearings and control cables are reportedly made of teflon. Teflon is finding growing use in office automation equipment particularly the rollers and bearings of copying machines. Bearings made of teflon practically need no lubrication. Polyvinyliden fluoride (PVDF) is another important fluorocarbon resin that is now widely used in Japan as a protective coating for electric wires and PVC pipes. Besides their use as lubricants, fluoroplastics are excellent dielectrics and are highly heat resistant in nature. Liquid fluorocarbons are noncombustible and freeze at very low temperatures and hence find numerous applications where these properties are essential. In addition, they are neither attacked by insects nor are affected by corroding agents.

Fluon gas is another important fluorocarbon material for use as a refrigerant. The use of fluon gas is expected to rise smoothly as fierceness of summer and standards of living keep rising. Fluon gas is also widely used for aerosol applications, as foaming agents and in solvent fire extinguishers, semiconductor—use—etchants and metal degreasing agents. In the past, the semiconductor use etchants were essentially the wet process agents such as hydrofluoric acid or ammonium fluoride. But recently, due to the spread of high density assembly, the dry process method using gases is gaining more popularity.

Silicones—the compounds of carbon and silicon

Silicones or silico carbons are another important group of polymers that are used for a number of applications. Like fluorocarbons, silicones also resist high temperatures over long periods. Some grades of silicone rubbers are stable upto 350°C and do not swell in organic solvents. Therefore, they are used in making hoses for fuel transport systems. The other important properties of organo silicone products are water repellancy, lubricity, low volatility and high boil-

ing point. Silicone liquids, therefore, find applications in high vacuum pumps, high temperature lubricants, water repellant fabrics and heat resistant enamels.

Conclusions

The use of man-made polymers as important engineering materials is widely recognised and a constant search is going on for synthesising newer and superior polymers for replacing the conventional materials with the associated technical and economical advantages. A few of the important newer polymer developments are in the fields of road coating

materials and agriculture to boost up farm production. In Russia use of polymeric ultra filter membranes in the production of soft cheese is reported to boost output by 8%-10% thereby saving a considerable amount of milk. Man has learnt from nature the skill of stitching molecules together and has excelled in developing materials that are useful. The man-made engineering materials will continue to contribute greatly to national economy and to the ever improving standards of living conditions.

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Carbon dioxide and crop yields

THE continuing industrial boom is increasing carbon dioxide in the atmosphere through the burning of fossil fuels. The felling of forests and decay of organic matter also add to this increase. Since 1958, the concentration of atmospheric carbon dioxide is being measured annually. Available data reveal that the concentration is increasing at an annual rate of about 1.5 parts per million (ppm). It is estimated that fossil fuels release five trillion (10^{12}) grams of carbon dioxide each year, while destruction of forests and oxidation of humans together release twelve trillion grams.

The problem is that carbon dioxide, in contrast to the other major atmospheric components, oxygen and nitrogen, absorbs infra-red radiation which is the principal out-going radiation from earth's surface to outer space. The increase of carbon dioxide in the atmosphere can thus be expected to result in a rise in the surface temperature. This phenomenon is known as 'Green-house effect' and during recent years serious attention has been focussed on this vital environmental change which according to cynics would result into melting of glaciers, increase in sea level and subsequent loss of fertile lands on globe.

While doomsday signals were received from some quarters, optimistic scientists asserted that the increase in carbon fixation by photosynthesis will be large enough to slow down the increase in atmospheric carbon dioxide produced by burning fossil fuels. Prof. Sylvan Wittwer of USA went ahead to conclude that an increase in concentration of atmospheric carbon dioxide from 330 ppm to 1000 ppm will greatly increase photosynthetic productivity and ultimately crop yields. This was not the first report on beneficial effects of increased carbon dioxide concentration. Even in plant physiology textbooks, it is mentioned that a linear increase rate of photosynthesis occurs upto 3500 ppm of carbon dioxide concentration, whereas a further increase causes leaf injury in plants. Various studies reported an increase in rate of photosynthesis at higher carbon dioxide concentrations. In soyabean, rate of photosynthesis was four times higher than normal at CO_2 concentration of 1670 ppm and in corn 20% increase in photosynthesis was observed at 510 ppm of CO_2 . Though encouraging, the results were not considered reliable since most of these studies were conducted in green-houses and photosynthesis was measured for short periods.

Long-term studies with cucumber revealed that after 5 days the rate of photosynthesis at 2400 ppm and 5500 ppm of CO_2 had fallen below normal. This trend continued as the time interval increased. Similar results were also reported from experiments conducted on soyabean and tobacco. However, the absolute rate of photosynthesis was always higher at a higher concentration of CO_2 . Researches in this field have suggested that decrease in rate of photosynthesis following prolonged exposures to high CO_2 concentrations was due to accumulation of starch in leaves. Because of excessive starch, leaves start deforming and finally begin to wither.

Long-term experiments with high concentrations of CO_2 give different results for various species. It is generally concluded that plants with the C_3 carbon pathway usually show a greater increase in rate of photosynthesis at higher CO_2 concentrations than plants with the C_4 pathway. In addition the response of high CO_2 concentration is greater in indeterminate plants such as cotton and soyabean than in determinate plants such as corn, sorghum, and sunflower.

Apart from the increase in the rate of photosynthesis, exposure of plants to high concentrations of CO_2 produces some morphological and physiological changes. The important morphological changes observed are increase in branching, greater stem length and increase in root/shoot ratio. While the leaf area increases due to high CO_2 concentrations, the time of flowering often gets affected differently in different plants. At higher CO_2 concentrations, partial closure of stomata which reduces transpiration, helps plants to grow normally under water-stress conditions. This phenomenon was observed by R. M. Gilford of Australia while working on wheat plants. The most striking effect of increased CO_2 concentration is on nitrogen fixation by soyabeans. R. W. Hardy and U. D. Havelika of Delaware, USA, have observed that soyabeans, which normally fix 25% nitrogen, fix five times as much nitrogen and are heavier and produce a higher yield of beans when

CO₂ concentration is increased three times above the normal. However, much work still needs to be done to fully elaborate this phenomenon. This, however, points out that it may be possible to fix more nitrogen at high CO₂ levels thereby reducing consumption of nitrogenous fertilisers.

To scientists and planners, the rate of increase of photosynthesis does not sound interesting but increase in growth and dry matter (biomass) production seems profitable. Obviously, that should be, since it gives a ray of hope to produce more from the same land to meet the growing food demands. Increase in dry weight by CO₂ doubling has been observed in case of soyabeans upto the tune of 382%, whereas an increase of 66% has been observed in sunflower. In another study, it was found that at 1000 ppm of CO₂, soyabean showed the highest increase in dry weight (72%) followed by velvet leaf (52%), whereas itchgrass and corn showed a decrease of 19% and 13% respectively. These studies clearly indicate that there is not necessarily a close relationship between increase in dry weight and rate of photosynthesis. More long-term research is needed to study the limiting factors when an excess of CO₂ is available.

Growth and dry matter production is not a direct function of the rate of photosynthesis. Instead, environmental factors like water, mineral nutrition, temperature and light are equally important in determining the growth of plants. Water and nitrogen are the two most significant limiting factors than CO₂ concentration. Nitrogen deficiency limits the formation of new tissues and hence the demand for photosynthesis; sulphur deficiency prevents plants from responding to a higher CO₂ concentration whereas water stress causes closure of stomata, which reduces the rate of photosynthesis and the demand for CO₂. In view of these observations, there seems little hope of deriving benefits at high CO₂ concentrations, because nitrogen and water often limit growth in most areas of the world.

Apart from carrying out detailed experiments, it is necessary to determine the responses and differences in the response of O₃ versus O₄ plants

and determinate versus indeterminate plants to high CO₂. Relative growth rates of responsive and non-responsive plant species have to be worked out to assess any changes in the ecosystems. In addition, long-

term co-relation studies are important to know the effect of high CO₂ concentrations and limiting factors.

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Methionine and its metabolism in man

METHIONINE is a sulphur containing amino acid essential for man and other mammals. Normally, twenty L- α -amino acids are found to be present in all kinds of tissue proteins, peptide hormones, enzymes, etc. But our body cannot synthesize ten amino acids including methionine. So, it originates from the food proteins which are digested to amino acids in the gastrointestinal tract. The blood methionine arises from the intestinal absorption so as to maintain the amino acid pool. From this pool, each tissue takes methionine along with other amino acids in proper proportions to synthesize the kinds of proteins needed for growth and maintenance of body function. Excess amino acids are deaminated in the liver to form the corresponding ketoacids and ammonia. All the ketoacids are ultimately oxidized to carbon dioxide and water in the process of ATP formation. In liver, ammonia is converted to urea which is excreted.

The human blood plasma level of methionine is 0.3mg-0.9mg/100ml. Ingestion of protein in each meal increases the plasma concentration of amino acids to maximum in 60 minutes. It falls to normal within 24 hours. But methionine is metabolized in a slow rate as is evidenced by the retention of this amino acid in the blood plasma many times above normal even 24 hours after its administration.

Methionine is a mysterious amino acid because it is still unknown why this amino acid is invited by the initiating codon AUG of mRNA to inaugurate the process of all kinds of protein synthesis. As a result all the newly synthesized proteins have the methi-

onine residue at their N-terminal end. Of course, here methionine does not enter as such, it is enzymatically formylated by N¹⁰-formyltetrahydrofolate at its α -amino group prior to incorporation at the N-terminal end of the protein to be synthesized. Besides its incorporation as the universal N-terminal amino acid, methionine may also be incorporated in other positions of any kind of protein according to the direction of mRNA involved in the process of that protein synthesis. Another interesting metabolic feature of methionine is that after conversion to S-adenosylmethionine (SAM), the active methionine readily donates its methyl group to the biosynthesis of various methyl-containing compounds like adrenaline, anserine, melatonin, creatine, choline, ergosterol, glycochamine, N-methylhistamine, N-methylnicotinamide, phosphatidylcholine, sarcosine, etc. The SAM is not only important as a methylating agent but is also a precursor of the polyamine spermidine.

Although L-methionine is an essential amino acid in the diet of all animals, its requirement can be fulfilled by feeding the corresponding ketoacid L-keto- γ -methylthiobutyric acid which is aminated to L-methionine. The dietary requirement for L-methionine may also be met by feeding D-methionine which is transformed into L-form through the intermediate formation of the ketoacid. The biologically inactive D-methionine is converted to the biologically active L-methionine. Sometimes, the presence of an amino acid in diet reduces the requirement for other. This is known as sparing action. Cyst when present in the diet decreases the need for methionine.

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In man methionine is metabolized in the liver after transamination with γ -ketoglutaric acid to form α -keto- γ -methylthiobutyric acid. It has been proved that only the S atom of methionine is utilized in the formation of cysteine, the rest of the cysteine molecule is derived from serine. The carbon chain of methionine molecule is then converted to homoserine which is degraded to propionic acid through the intermediate formation of α -ketobutyric acid. Propionyl-CoA formed from propionic acid is carboxylated to methylmalonyl-CoA, which is then isomerized to succinyl-CoA. Being an intermediate of the tricarboxylic acid (TCA) cycle, succinyl-CoA is oxidized there. Succinyl-CoA can also be utilized along with glycine in the formation of porphobilinogen. The head-to-tail condensation of four molecules of porphobilinogen yields protoporphyrin nng of the blood haemoglobin molecule.

Patients with severe liver disease 'fetor hepaticus' (as evidenced by the offensive smell of breath) excrete methyl mercaptan in their urine. This substance is formed by the enzymatic

hydrolysis of α -keto- γ -methylthiobutyric acid derived from methionine.

In addition, one of the structural units of proteins, methionine takes part in many important metabolic reactions. Its deficiency may cause imbalance in the whole metabolic system. Vegetable proteins are found to be very poor in methionine content. So, it should be supplemented in pure form in the diet of man for normal function of the body. Chemically synthesized racemic mixture (equimolecular amounts of D- and L-forms) of methionine as a dietary supplement is being used in the developed countries like the USA and Japan. Microorganisms can synthesize L-methionine starting from L-aspartic acid through a series of enzymatic reactions. Therefore, microbial production of L-methionine will be a great achievement to meet the dietary deficiency of this amino acid among the people of underdeveloped countries.

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host. Later, in 1978, Charles L. Wilson of United States proposed three major groups: (i) teratomas under host control, (ii) teratomas under pathogen control, and (iii) teratomas under foreign control. This seems to be the most functional grouping as these three classes focus on the nature of host-pathogen interaction.

Teratomas under host control

These teratomas appear as exaggerated forms of normal growth such as fasciation, phylloidy, hairy root, etc. It is self-limiting when undifferentiated tissues develop. Certain insects and pathogens may initiate formation of teratomas, but even then a few of them are under host control. Others are induced genetically or by chemical, physical and mechanical means.

The autonomous tumors under host control develop only when the host acquires certain new synthetic capabilities. In non-tumorous plants the autonomous growth is suppressed possibly due to the loss of certain synthetic capabilities. Acquisition of new synthetic capabilities leads to induction of tumor.

Teratomas under pathogen control

Teratomas such as nodules

Plant teratomas

IN biological senses, man is a controlled animal. Cells that constitute the body of a man impose the greatest form of control over him. But this is realised only when the cells do not function normally and exhibit cancerous growth or 'teratomas'. Considerable resources have been spent in trying to understand cancer because of its threatening nature. 'Plant Cancers' are definitely a valuable tool in this quest.

The first systematic classification of plant teratomas was made in 1969 by A.C. Braun of United States who is a pioneer in studies of abnormal growth in plants. He grouped plant teratomas into two broad classes: (i) nonself-limiting (autonomous) teratomas which produce growth over which the host has no control, and (ii) self-limiting teratomas where tumors are controlled to a great extent by the



Fig.1. Phylloidy in sesamum incited by a mycoplasma-like organism (Left—healthy shoot; Middle & Right—infected shoots)



Fig.2. Root knot in tomato incited by a nematode

induced by *Rhizobium*, root-knots induced by nematodes, and a few galls induced by insects are under control of the pathogen. In these cases, the pathogen dictates structure and development of the tumor for its own benefit. The tumors stop growing when the need of the pathogen is satisfied. The effect on the host may be beneficial (as in *Rhizobium* nodules) or destructive (as in nematode root-knots). That these tumors are under pathogen control is supported by the facts that (i) if the pathogen is removed further organized development of teratomas, and (iii) organized structure which are developed cannot be formed by the host alone.

Teratomas under foreign control

Certain teratomas are new organisms as they are synthesized with a new genome derived from the genomes of both the host and the pathogen. Such teratomas exhibit autonomous growth and are said to be under foreign control. The notable examples in plants are crown gall and the wound tumor virus diseases. In these cases extra chromosomal elements (ECEs) play a vital role. These ECEs are extracellular genetic elements (whether DNA or RNA) which control the formation of teratomas. ECEs include all viruses, viroids, plasmid DNAs, transfer factors and insertion sequences.

Viruses are the classic examples of ECEs. When the viral genes combine with host genes and the newly formed host virus genome is perpetuated through cell divisions, the teratoma is said to be under foreign genetic control. However, in case of plant teratomas the nature of incorporation of ECEs into host chromosomes is still not understood.

Teratomas and cellular differentiation

The knowledge of how cells acquire autonomy may provide a vital clue about how cells control themselves during differentiation. It is considered by some workers that autonomous growth of teratomas is the reversion of embryonic growth in cells heading for differentiation. A gradual loss of certain metabolic capabilities seems to be involved during differentiation. However, in the process of becoming autonomous the cells gradually acquire new metabolic capabilities. Possibly, genes for renewed growth which are normally repressed in differentiated tissues are "turned on" in autonomous cells. Differentiated cells have a greater dependence on exogenous sources of growth substance than autonomous teratoma cells. This is speculated as the key to the control mechanism of differentiation operating in higher organisms.

Differentiated animal tissues lack the ability to regenerate. Most of the animal diseases are due to the inefficiency of cellular repair system. If the present knowledge reaches a stage where cellular differentiation following the artificial induction of cancer can be controlled, it would usher in a new era in animal tissue and organ repair. With the help of a carcinogen regenerative growth could be artificially initiated in non-regenerative tissues and by controlled differentia-



Fig.3. Gall on citrus shoot incited by a virus

tion the new cells may be induced to yield desirable new tissues. It would indeed be a landmark in the history of mankind. Man would be in full control of his own cells! A splendid end of the cancer story that would be.

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Soil indicator plants

PLANTS grow in a wide variety of habitats. This ability is achieved through development of certain modifications in plants that suit best the surrounding. Failure to adapt to a new altered situation is reflected through certain phenotypically identifiable expressions or symptoms. In other words, types and pattern of vegetation of a locality indicate its environmental attributes. Of the several factors determining the prevailing environment, soil, the nutrient source of plants, is the most important. Plant nutrients occur in the soil both in dis-

solved and bound forms, only a tiny fraction (less than 0.2%) of the nutrient supply is dissolved in water. Most of the remainder is rich in organic matter detritus, humus, and relatively insoluble organic compounds or incorporated minerals. On the basis of mineral requirements some essential elements, e.g., N, P, K, S, Ca, Mg and Fe have been termed as macronutrients (required in large quantities) and a few others, viz., Mn, Zn, Cu, Mo, B and Cl as micronutrients (required in traces only). Besides, there are elements essential

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only for certain plant groups, like Na for Chenopodiaceae, Co for Fabaceae with symbionts, Al for ferns, Si for diatoms and Au for *Equisetum*. Likewise, certain plants withstand the presence of heavy metals in higher concentrations, e.g., some spp. of *Silene* to Zn, serpentine plants to Cr and Ni; many liverworts and mosses to Cu; *Festuca* sp. to Pb and acidophilic grasses to Al. Some plant species can be of diagnostic value as they reveal the quality of substrate on which they grow and are called 'soil indicator' plants (F.E. Clements, 1920, Ecologist Division of Plant Biology, Carnegie Institution of Washington, USA).

On the basis of soil reaction (pH), soils are classified as acidic, alkaline and saline, and corresponding indicators are known as acidic, alkaline and saline indicators or halophytes respectively.

Acid indicators

Most soils in humid regions are either weakly acidic or neutral, but the bog soils are markedly acidic (pH, 3.0). In very acidic soils, too much Al^{3+} is liberated while Ca^{2+} , Mg^{2+} , PO_4^{3-} and MoO_4^{2-} are depleted, certain other trace elements are fixed in relatively insoluble compounds so that plants are more poorly supplied with these nutrients. Different species display characteristic tolerance limits in their physiological behaviour to soil pH. Most vascular plants are 'amphitolerant' having broad optimum in the range between pH 3.5-8.5. Some species of *Sphagnum* (peat moss) prefer very strong acid milieu and are found in bogs. *Sphagnum* species are very sensitive to OH^- succumb even in neutral range, and are regarded as strongly 'acidophilic'. The grasses, *Deschampsia flexuosa*, *Calluna vulgaris*, *Sarothamus scoparis*, also indicators of acidic soils, develop optimally between pH 4-5, but can also grow in neutral range and will tolerate weakly alkaline soils. They are called 'acidophilic-basitolerant'. *Polytrichum*, *Rhodomitrium* and most species of Pinaceae, Ericaceae strongly decrease soil pH on which they grow.

Alkali indicators

Alkali soils are those which have

enough Na or K to be injurious to 'glycophytes' (non-halophytes) but, with negligible free salts and pH, are usually above 8.5. Such poorly drained soils may give basic reaction as a result of either CaCO_3 or Na_2CO_3 . In very alkali soils Ca^{2+} , Mg^{2+} , K^+ , Na^+ are liberated in large quantities; while Fe^{2+} , Mn^{2+} , PO_4^{3-} , Si^{4+} , Al^{3+} and certain other trace elements are fixed in relatively insoluble compounds. Consequently plants are poorly supplied with these nutrients.

Various species of bacteria with an optimum tolerance toward the alkaline end of the scale are called 'basiphilic'. They are damaged if the pH falls below 6.0. *Tussilago farfara* has an optimum between 7.0-8.5 alkaline range. It can also grow in neutral soil and a good tolerance down to pH 4. It is called 'basiphilic-acidotolerant'. Certain plants grow only on basic soils containing free CaCO_3 or on circumneutral soils from which Ca has not yet been lost, they are known as 'calciphites', e.g., many bryophytes with tufaceous deposits of calcite (CaCO_3)-*Barbula gracilena*, *Bryum cellulare*, *Vesicularia montagnei*, *Asterella maculata*, *Fissidens taxifolium*, *Pellia endiviaefolia*, *Chiloscyphus polyanthus*, among angiosperms many members of Brassicaceae and Fabaceae. Converse behaviour is shown by most Chenopodiaceae, Polygonaceae, Caryophyllaceae, *Deschampsia flexuosa* and peat moss. They are hypersensitive to Ca^{2+} and HCO_3^- and are known as 'calcifugous' plants.

Saline indicators (Halophytes)

Saline soils are those that have accumulated sufficient salts to interfere osmotically with the growth of non-halophytes (glycophyte) but are not highly basic in reaction. The pH is usually below 8.5 and a white crust of salt is drawn to the surface during dry weather. The degree of salinity is also reflected on the distribution of different species starting from chenopodiaceae (weakly saline) to highly saline mangrove vegetation, e.g., *Rhizophora mucronata*, *Sonneratia alba*, *Avicennia* sp. and *Laguncularia racemosa*, etc. The following species are often observed growing in saline environment: *Allenrolfea occidentalis*, *Atriplex confertifolia*, *Capparis aphylla*, *Crissa vestita*, *Distichlis spicata*, *Kochia vestita*, *Salsola* sp., *Salicornia rubra*, *Sarcobatus vermiculatus*, *Sporobolus airoides* and *Suaeda* sp.

However, all these species grow even better in a non-saline environment than in a saline one. The presence of one or more of them is not necessarily an indication of salinity. Another clue to salinity is the absence of salt sensitive plant spp. Halophytes are classified in two major categories as follows:

(a) *Acid halophytes*. They contain much more equivalent anions Cl^- and SO_4^{2-} than inorganic cations K^+ and Na^+ .

(i) *Chloride indicators*: Chloride salinity of soils enhances growth in *Salicornia herbaceae*, *S. europaea*, *Salsola turcomanica*, *Halocnemum strobilaceum*, *Halidium caspicum*, *Kalidium caspicum*, *Halostachys belangeriana*.

(ii) *Sulphate indicators*: *Anabasis aphylla*, *Salsola rigida*, *Karelinia caspia*, *Halimocnemis mollissima*, *Salsola dendroides*, etc., can tolerate extra sulphate concentrations.

(b) *Alkali halophytes*. They contain more equivalent cations like K^+ and Na^+ than inorganic anions Cl^- and SO_4^{2-} e.g., *Suaeda microphylla*, *Haloxylon aphyllum*, *Anabasis salsa* and *A. aphylla*, etc.

Metallic indicators

Some spp. of mosses and liverworts associated with copper bearing substrates are claimed to be indicators of sites of metallic enrichment and have earned the name copper mosses. Copper mosses give geologists, mining engineers and prospectors a chance to look for new ore deposits. They have been used with success in locating copper deposits in Europe. New copper mines were discovered by noting localities of copper mosses from herbarium material e.g., *Mielichhoferia elongata*, *M. mielichhoferi*, *Scopelophila ligulata*, *Drytodon atratus* and liverworts like *Gymnocolea acutiloba*, *Cephaloziella massalongii*, *C. phyllacantha* and *Marchantia alpestris*.

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Senna—a valuable medicinal crop of drylands

SENNA botanically known as *Cassia angustifolia* Vahl (family *Caesalpiniaceae*), a native of West Asia, is being cultivated mostly in Tamil Nadu and to a smaller extent in Karnataka, Andhra Pradesh and Gujarat 'Sennoside', a drug used as laxative, is extracted from its leaves and pods. Sennosides are classified under stimulant cathartics and represent 44.24% of the total laxative category. They are anthracene derivatives and are known as 'dianthroglucosides.' Almost 75% of the senna produced in India is exported, the total export for 1978-79 valued at Rs.20.08 million. This amount is expected to go up further due to increasing demand for this medicinal plant in American and European countries and hence has a great potential as a foreign exchange earner. The current world demand is estimated at 10,000 tonnes of leaves and pods per annum.

The plant

Senna is a drought hardy, deep rooted perennial and can survive hot summer and prolonged dry periods. It does not stand continuous rains and is suitable for semi-arid and arid lands. The plant is an erect shrub bearing bluish green leaves and bright yellow flowers (Fig. 1). It starts flowering when 90 to 100 days old. The green pods on maturity turn brownish-black and contain 5 to 7 seeds. Seeds exhibit hard seed coat and dormancy. Hence, seed germination can be improved by rubbing seeds with coarse sand or by acid treatment.

Cultivation

The crop grows in a wide variety of soils such as red or alluvial loams, black or gravelly soils and laterite tracts. As a rainfed crop it is usually sown during October-November in South, seed rate being 20kg/ha-30 kg/ha. While in North it can be grown after the harvest of rabi crops following pre-monsoon showers in June. Broadcasting is usually done, but sowing in rows of 30 cm apart is bet-

ter as indicated by experimental trials. Normally, one or two interculture operations are done. The crop is not manured generally, though the plant is reported to be responsive to nitrogen and phosphorus application.

Harvest and curing

The first picking of leaves is done after three months from the date of sowing. Later pickings are usually taken at intervals of one month. Three-to-five pickings of leaves can be taken and the pods are collected along with final pickings. The time of harvest is very critical with respect to sennoside content. Rains before harvest may reduce the active principle in leaves and pods. Pods are harvested before full maturity (when about 25 days old) for maximum sennoside content. After harvest, leaves and pods are immediately dried in shade for 4 days and 10 days respectively. Sun drying

lowers quality. Great care has to be taken to maintain the green colour of leaves. Poor attention to drying results in darkening of the produce colour and lowering its market value.

Yield and economics

In South, the yield of a rainfed crop on an average is about 5-6 quintals of leaves and 1-2 of pods per hectare. The average cost of cultivation reported is about Rs. 500 to Rs. 600/ha. The margin of profit is attractive with the price level of Rs. 700 and Rs. 800 per quintal of leaves and pods respectively. Higher sennoside content in the produce fetches a higher price. Preliminary trials conducted at Jodhpur yielded 1394 kg/ha of dry foliage and 894 kg/ha of pods under rainfed desert conditions. An yield of 1788 kg/ha of dry leaves was however reported under irrigated conditions in Gujarat.



Fig.1. *Cassia angustifolia* Vahl.

Diseases and pests

Incidences of diseases and pests appear to be more common in North. Seedling damping off, die back, leaf blight and leaf spot diseases are observed. The caterpillar stage of a moth (*Pieris* sp.) causes considerable damage to the young leaves reducing the yield. Thus fungicide and insecticide sprays may be required for control.

All India Coordinated (ICAR) trials of this plant at different locations in

North have indicated a good scope for fitting this valuable export worthy crop on a commercial scale in the local cropping systems. There is need to develop various cultural practices, manuring, irrigation and plant protection measures suitable to the local conditions. Breeding for high yielding and disease-resistant varieties should also be taken up. Attention should also be given to the post-harvest technology of the produce and for standardising the value of produce based on sennoside. Thus farmers have to take

efforts to extend the area under this crop and growing it with better attention to improve yield and quality thereby earning good profit for themselves and valuable foreign exchange for the country.

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FISH BREEDING (Continued from page 653)

shells and the dead eggs are removed when the hatching is complete. The hatchlings remain in outer hapa undisturbed till the 3rd day after hatching. During this period, they subsist on the food stored up in their yolk sac. By the 3rd day, mouth is formed and the hatchlings begin directive movement and feeding. At this stage they are carefully collected from the outer hatching hapa and stocked into prepared nurseries.

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NEWS & NOTES

Nobel Prizes—1984

Physics

THE 1984 Nobel Prize in Physics has been jointly awarded to two experimental physicists, Prof. Carlo Rubbia of Harvard University, Cambridge, USA and Simon Van der Meer of the CERN, Geneva, Switzerland, for detection in 1983 of the massive W^+ and Z^0 vector bosons, collectively known as 'Weakons' at the CERN's super proton-antiproton collider facility. CERN is an acronym for Europe's prestigious and versatile particle accelerator center, European Organization for Nuclear Research. The discovery of W^\pm (charged) and Z^0 (neutral) bosons (masses ranging 80 GeV-95 GeV as against proton's 0.931 GeV) as carriers of the unified electro-weak force is apparently a conclusive evidence for the correctness of the well-known Weinberg-Glashow-Salam gauge theory that unites electromagnetic and weak interactions into a single force. Although the gauge theory (now well established as the so called 'standard model' of the electroweak interaction) predicted the existence of vector boson intermediates as early as 1967, their large masses eluded detection at the world's most powerful accelerators at CERN, Brookhaven, Standard Linear Accelerator Centre, Fermilab, etc.

The Nobel Prize citation honoured Prof. Rubbia for spearheading a large project for conversion of CERN's giant 400 GeV Super Proton-Synchrotron (SPS) into a collider in which a

270 GeV proton beam from the synchrotron is made to collide (several thousand times a second) with bunches of 270 GeV antiprotons. The collision leads to the rare events in which a W^+ or Z^0 particle is created. Prof. Van der Meer, an accelerator physicist, is given the credit for development of 'stochastic cooling' method for bunching monoenergetic beams of antiprotons required for the collider.

Carlo Rubbia was born in 1934 in the famous town of Pisa, Italy. After early education there he joined the faculty of the University of Rome in 1960. During 1967-70 he worked as a senior experimental physicist at CERN and then at Harvard as Professor of Physics. Since 1976 he has associated himself again with CERN and now divides his time between the two places. Prof. Simon Van der Meer, who hails from the Netherlands, was born in 1925 in the small Dutch town Guelph near The Hague. After his early education as mechanical engineer at the University of Guelph, he joined CERN in 1956. At CERN he specialized himself as an accelerator technician.

The decision to build colliders had an interesting origin. In principle it is possible that in conventional particle accelerators, W or Z particles can be created like any other exotic subatomic particle (hadrons and heavy

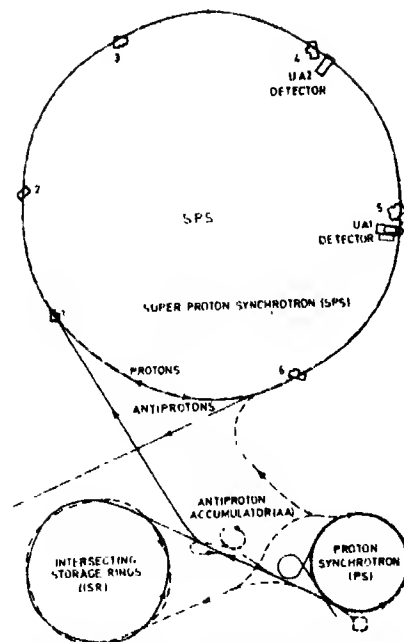


Fig. 1. Diagram of CERN Proton (p) and antiproton (\bar{p}) collider assembly (Courtesy: CERN, Geneva, Switzerland)

mesons) in high energy collisions against a fixed target. However, a major part of the energy released in the collision is wasted away as kinetic energy of myriads of other debris particles, leaving aside only a small portion for the generation of exotic particles. Thus only particles not heavier



Van der Meer (Left), Carlo Rubbia (Right) (Courtesy: CERN, Geneva, Switzerland)

than γ particle (10GeV) can be created in such collisions in a conventional accelerator. Alternatively, in a head-on-collision as in a collider, since both the particles are momentarily brought to rest, much greater energy is available for the creation of exotic particles. Furthermore, when a colliding particle, say a proton (p), meets an antiproton (\bar{p}), they annihilate each other and bulk of the liberated energy is available, in principle, for the creation of W or Z bosons (80-95GeV). But, in practice, only a few (5-20) W-events occur as against debris of other hadrons, mesons, leptons and neutrinos. Prof. Rubbia's calculations indicated a 'resonance' effect with the probability of vector boson generation reaching a peak when proton/antiproton beam energy was 270GeV each. This was, of course, too much for the existing particle accelerators. But it could be easily achieved in a \bar{p} -collider, wherein a circulating proton beam in a magnetic field is made to meet an antiproton beam at a desired point.

For a meaningful detection of W-events, it is necessary to ensure an adequate number of colliding protons and antiprotons, (at least 1 billion!) and as the collision probability is small (1 in 1000), adequate 'bunching' of antiprotons is needed. Unfortunately, antiprotons do not occur in nature like protons. Again, when antiprotons are liberated through protons impinging against a fixed metallic target, only 2-3 antiprotons are generated for millions of collisions, so that they must be first accumulated and stacked for bunching. Furthermore, the antiprotons have a large velocity spread like random motion in a gas, which must somehow be 'precooled' prior to injection as 'monoenergetic beam' to collide with proton beams in the SPS-collider.

For the colliding experiments at CERN, proton/antiproton beams are made to traverse a sequence of coupled beam manipulatory devices. First, a beam of 26 GeV protons from CERN Proton-Synchrotron (PS) ring (bottom right in Fig.1) is directed against a copper target to generate low energy (3.5GeV) antiprotons which are magnetically transferred to a wide aperture tubular ring called

antiproton accumulator (AA). Then, the antiprotons are precooled by stochastic method and passed on to a slightly smaller orbit, and finally stacked in the accumulator with the previous bunch. After a few hundred billion antiprotons are bunched (a process that takes around 24 hr), they are again sent back to PS for acceleration into 26GeV antiproton beams. The beam is then injected into the ring of the 400 GeV Super Proton Synchrotron (SPS) wherein simultaneously protons (26GeV) from PS too are injected into the SPS albeit in a 'counter-rotating' sense (the two beams circulate in slightly eccentric orbits). The beams are then accelerated to the desired resonating energy of 270 GeV, and, through electromagnetic couplers made to collide head-on at preset locations (wherein the particle detector chambers UA1 and UA2 are placed) in the SPS ring.

More than a billion proton-antiproton collisions have been recorded at CERN out of which only a handful (about a hundred) have survived the painstaking data analysis designed to discard all but a special kind of event in which the W or Z⁰ is created (plus hadrons) which then decays into leptons and a neutrino.

R. Sambasivan

Editor

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Chemistry

The 1984 Nobel Prize in Chemistry has been awarded to R. B. Merrifield, Professor of Biochemistry at the Rockefeller University, USA. He gets the award for his pioneering researches in the field of solid phase peptide synthesis and in the study of the relationship between structure and function in biologically active synthetic peptides and proteins.

Nearly two decades ago, in the early '60s, Merrifield put forward the idea, of synthesizing peptide chains on a polymer support. His technique involved the stepwise attachment of the carbonyl part of the C-terminal



R.B. Merrifield

amino acid to a polymeric resin particle by a covalent bond. The succeeding amino acids (N-terminal protected) were added one at a time in a stepwise manner. At the end of each step, a protected peptide sequence with one amino acid moiety more than the previous step remained attached to the resin. This series of reactions was repeated till the desired amino acid sequence was obtained. Simple filtration and washing removed excess reagents and byproducts. The complete synthesised peptide was freed from the polymer support by using appropriate cleaving agent and purified by well known purification methods such as electrophoresis, ion exchange chromatography, counter current distribution or any other suitable method for peptide purification.

Merrifield's method proved to be a very efficient one for the synthesis of peptides with 4-10 amino acids. Merrifield himself demonstrated this by synthesizing bradykinin, a 9-amino acid peptide hormone, in just 8 days (see box). This elegant synthesis, now named after him, was later extended to peptides with more than 10 amino acids also. The solid phase synthesis method has been later used to synthesize human insulin also. As the Royal Swedish Academy of Sciences observed "Merrifield's method has greatly stimulated progress in biochemistry, molecular biology, pharmacology, and medicine. It is

Solid phase peptide synthesis

Professor Merrifield first demonstrated the feasibility of his ingenious method by synthesizing a tetrapeptide (L-leucyl-L-alanylglycyl-L-valine). A nitrated and chloromethylated copolymer of styrene and divinylbenzene was treated with the triethylammonium salt of the C-terminal amino acid in the proposed polypeptide sequence to give the stable covalent benzyl ester linkage. This bond held the growing peptide chain in the solid phase on the support resin. The carbobenzoxy group protecting the reactive basic part of the C-terminal amino acid was removed in the next

step by HBr in glacial acetic acid. Treatment with the next protected amino acid lengthened the peptide chain by one amino acid residue. This sequence of deprotecting and coupling reactions completed one cycle. Repetition of this cycle with appropriate carbobenzoxyamino acids yielded the completed protected peptides which were decarbobenzoxylated by HBr and the peptide chains freed from the resin by saponification. The newly synthesized peptides were then purified by a suitable peptide purification method.

S.N.V.



Cesar Milstein

also of practical importance, both for the development of new drugs and for gene technology".

Robert Bruce Merrifield was born at Fort Worth in Texas, USA, on July 15, 1921. He graduated from the University of California, Los Angeles (UCLA) in 1943. He then joined the Philip R. Park Research Foundation as a chemist. Soon he received a Teaching Assistantship from the chemistry department of UCLA. Merrifield retained this for the next three years, but later, moved on to the Medical School of UCLA where a Research Assistantship in chemistry was offered to him. He stayed there for a brief period only (1948-49). In 1949, Merrifield received his Ph.D in Chemistry. In the same year he was awarded an Assistantship in Biochemistry at the Rockefeller University which he accepted. Merrifield became an Associate in 1953 and Assistant Professor in 1957. In 1966 he was made Professor of Biochemistry at the same University, a post which he retains even today.

A member of the National Academy of Sciences, USA, Merrifield has held positions of Nobel Guest Professor, Uppsala University (1968) and Associate Editor of *International Journal of Peptide and Protein Research* (1969). He has been the recipient of many awards—including the Lasker Award for Basic Medical Research (1969), Gairdner Award (1970), IntraScience Award (1970), Award for Creative Work in Synthetic Organic

Chemistry from the American Chemical Society (1972), and Nicholai Medal (1973).

S.N. Venkataramanan

Medicine

The Nobel Prize in Physiology or Medicine for 1984 has been awarded jointly to three immunologists—Niels Kai Jerne of the Basel Institute for Immunology, in Switzerland, Cesar Milstein of the Medical Research Council Laboratory in Cambridge, England, and Georges Kohler, also of the Basel Institute.

Seventythree year old, Danish born Jerne is a theoretician who is credited with developing two very important concepts in immunology, namely, that of self-tolerance and of cell networks. The whole science of immunology is based on the fact that the body reacts and produces antibodies only against 'foreign' substances but not against itself. Scientists had long puzzled as to how the body was able to recognise the foreign from the host. Jerne's selection, or self-tolerance, theory provided the answer. He postulated that during very early development of the embryo, lymphocytes which reacted to 'self' molecules are eliminated so that no more of them are produced in later life. This idea was first put forth by Jerne in

1955, in his paper "Natural selection theory of antibody formation." Later, in 1963, he developed the 'hemolytic plaque technique' for detection and quantification of extremely small amounts of antibodies secreted by single cells. The 'network theory' of the immune system which Jerne proposed in 1974 envisages a mechanism by which excessive production of lymphocytes in response to an antigen is prevented. Unrestricted production of lymphocytes is known to lead to malignancy. Jerne postulated that there are certain cells in the body which produce antibodies against a wide range of other antibodies leading to a network of cells which prevent any runaway proliferation of lymphocytes.

The contributions of Milstein and Kohler are mainly in the field of 'hybridoma technology' which has opened up immense possibilities in the large-scale production of antibodies for a variety of applications. 57-year old Argentinian born Milstein, who now heads the proteins and nucleic acids chemistry division of the Medical Research Council Laboratory of Molecular Biology at Cambridge, started his researches in immunology in 1963 soon after he came back to Cambridge from Buenos Aires. His work has been primarily concerned with the genetic regulation of the biosynthesis of immunoglobulin in malignant tumors of bone marrow known as myelomas. It was known earlier that myelomas cells secreted antibody. But it was almost impossible to identify the antigen that led to their



Niels Jerne (Left) and Georges Kohler (Right)

production because of the difficulty in getting the specific antibody in sufficient quantity

The solution was found in 1975, soon after 37-year old West German, Kohler joined Milstein's group in Cambridge. They were able to produce in the laboratory a somatic hybrid by the fusion of antibody producing lymphocyte cells from immunized mouse and myeloma cells. The new hybrid cells, which acquired the antibody producing capability of lymphocytes and the unlimited growth characteristic of myeloma cells, was named 'hybridoma'. The importance of the technique lies in the fact that for

the first time it was possible to grow in culture almost in limitless quantities cell strains capable of producing any specific antibody against a single antigen. Monoclonal antibodies produced by the hybridoma technique have already revolutionised medical diagnostic methods. They are today used in laboratories and hospitals around the world to investigate a wide range of ailments, including infectious diseases, autoimmune disorders, and cancer. For the future they hold many promises, including a vaccine against malaria and a cure for leukemia.

Biman Basu

Obituary

P. A. M. Dirac

IN 1928, a 26-year old Englishman published a paper in the *Proceedings of the Royal Society*. It suggested in some amazing ways a symmetrical solution of quantum mechanical wave function under the special relativistic conditions. When the theoretical model was applied to

electrons, the outcome was puzzling. Its solutions led to four different states of the electron. Two of them were positive energy solutions and were shown to be the exact descriptions of two spin states of the electron resolved earlier by Wolfgang Pauli of Germany. The other two states were

negative energy solutions. When reformulated they became positive energy descriptions of entities with opposite electric charges of the same magnitude as that of electron. Some physicists thought them as describing the proton, but dynamical behaviours depicted by the model could not fit with those of the proton. Within two years, in 1932, Anderson and his team in the US discovered the new particle which was called anti-electron or positron. Soon afterwards, Robert Oppenheimer (later famous as the progenitor of the atom bomb) mathematically showed that the positrons were nothing but the particles represented by the negative solutions of the 1928 paper in *Proc. Royal Soc.* of the young Englishman. As all students of physics now know, the young Englishman, probably the most brilliant of the new generation of mathematical physicists of that period besides Pauli and Fermi, was Paul Adrien Maurice Dirac.

Dirac was born on 8th August 1902 in Bristol, England. He graduated from Bristol University in 1921 and went on to join Cambridge University. Soon he was seen in the select group of young theoretical physicists at Göttingen in Germany. There assembled under eminent physicists like Max Born, Felix Klein and others were almost all the future stalwarts of theoretical physics such as Wigner, Gamow, Oppenheimer, Heisenberg, Jordan, Pauli and others. Returning



P.A.M. Dirac

NEWS AND NOTES

back to Cambridge, Dirac became an institution by himself. He got his Ph.D. from Cambridge in 1926.

Before Dirac, there had been several attempts to combine the two fundamental developments of the special theory of relativity and the old quantum theory into a single coherent theory, but without any success. The reason was simple. Lorentz transformations of the special relativity make the equations both space and time-symmetric, whereas the quantum mechanical description has symmetric space parameters and asymmetric time parameter. Dirac's theory was modelled in such a way that the wave equation was linearised and the result was both space and time-symmetric fulfilling the conditions of Lorentz transformations.

The results were more spectacular than predicting the existence of positrons. Dirac applied the model to the behaviour of electrons in hydrogen atom. The precise measurements of Uhlenbeck and Goudsmit and of Hertz and Frank which disagreed with the results calculated on the basis of earlier models, fitted exactly by Dirac's calculations.

In 1926, Dirac derived the equations of the Fermi statistics from quantum mechanics by a completely different approach and probably independent of Fermi's paper. Hence the name Fermi-Dirac Statistics. It was Dirac who suggested the names Boson and Fermion for particles obeying Bose-Einstein and Fermi-Dirac statistics respectively. His other works include a correct theory of matter-radiation interaction and a theory of magnetic monopoles. His later works were on general relativity and gravitation where he suggested, like Gamow, variability of the gravitational constant G .

Dirac was awarded the Nobel Prize for Physics in 1933 along with Erwin Schrodinger, the discoverer of wave mechanics. He was made a Professor and occupied the prestigious Lucasian Chair of Mathematics at Cambridge at the young age of 30. He travelled extensively and was visiting professor at many universities including Michigan in 1929 and Princeton in 1931. In 1972, on his 70th birthday, scientists from all over the world

assembled in Rome to pay tribute to him. A large felicitation volume that was published on the occasion provides an overview of the spectacular range of Dirac's contributions to twentieth century physics.

There are many interesting stories about Dirac which reflect upon his gentle personality. Once, when some of his Göttingen friends visited his home in the early thirties, his wife (sister of the famous physicist Wigner) who was also there, went inside before being introduced to the visitors. One of Dirac's friends thought he had seen the lady earlier (which was certainly possible) and asked his host who the lady was. Dirac replied, "She is my..... I mean, Wigner's sister." Modest Dirac considered Wigner more famous as a physicist than himself!

Dirac visited Calcutta during the early sixties and spent his evenings with Prof. Satyen Bose. On one occasion, Bose was to drive Dirac and his wife home in his own car. Bose took to the wheels with Prof. and Lady Dirac in the back seat of the car. But before driving off Bose invited several of his students also to join in and asked them all to occupy the front seat. When Dirac pointed out that there was enough space in the back seat, Bose remarked "We believe in Bose-Einstein Statistics. Dirac at once started explaining to his wife that in Bose-Einstein Statistics particles are allowed to crowd together while in Fermi-Dirac Statistics at the most only two particles can be allowed together!

Subir K. Sen
Calcutta

Sixth All India Congress of Zoology

THE Sixth All India Congress of Zoology sponsored by the Zoological Society of India was held at Gwalior under the auspices of the Jiwaji University from 19 to 22 October 1984. Presiding over the inaugural function, Dr. P.N. Srivastava, Vice-Chancellor, Jawaharlal Nehru University, underlined the need for reorienting Zoology courses in Indian Universities if our scientists are to keep pace with the tremendous rate at which scientific research is progressing in advanced countries. Dr. K.K. Tiwari, Vice-Chancellor, Jiwaji University and General President of the Congress of Zoology, stressed the need of organised research and the role of scientific societies in the same. The congress felicitated Dr. Birendra Singh Chauhan, Member State Planning Board, Madhya Pradesh and a very senior active zoologist of India. The following gold medals of the Society were awarded: All India Congress of Zoology medal to Dr. B.K. Tikader, Director, Zoological Survey of India for research contributions in arachnology; Dr. B.S. Chauhan medal to Dr. H. Khajuria formerly

Deputy Director, Zoological Survey of India for researches on Chiroptera and Primates of India; Dr. G.D. Bhale-
rao memorial medal went to Dr. G. Mazumdar, Professor of Zoology, Burdwan University, Burdwan and Dr. N.K. Sukul, Reader, Department of Life Sciences, Viswabharati University, Santiniketan, for contributions to the field of nematology. Fourteen zoologists were admitted to the Fellowship of the Society.

In the four-day session of the Congress, 361 scientific papers were presented in 16 different sections. Dr. P.V. Dehadrai, Fisheries Adviser to the Government of India, in a special lecture dwelt upon brackish water aquaculture in different parts of the world and Dr. P.J. Deoras gave an illustrated lecture on environmental pollution. The Zoological Survey of India held an exhibition of its recent publications on the occasion.

B.K. Behura
President
Zoological Society of India
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MEDICAL NOTES

Heating supports radiotherapy of tumours

THE use of hyperthermia, either alone or in combination with radiations or chemicals, in cancer therapy has been suggested at regular intervals over the years, but has never in the past found a permanent place in the management of cancer. The curative effect of heat on cancer patients was discovered in the 19th century, when toxin induced high fever resulted in the regression of malignant tumours. Fever therapy of cancer was suggested in 1891, when Coley noted that regression of an inoperable 'round cell carcinoma' of the neck was associated with a febrile bout of erysipelas. At this stage it was not clear whether the shrinkage of the tumour was due to fever or due to a direct effect of the bacterial toxins. The advantage of combining heat with radiation was realised in the early 20th century when Muller (1910) reported complete regression of advanced tumours in 1/3rd the patients treated (32 out of 100) and rapid but temporary improvement in another 1/3rd. Currently, a lot of attention is being concentrated on this treatment modality, the most recent revival of interest being based partly on documented evidence of tumour regression and partly on encouraging results from extensive laboratory experiments with both *in vitro* (culture) and *in vivo* systems.

At the clinical level, application of hyperthermia to the treatment of cancer can be divided into two broad categories, viz., whole body systemic hyperthermia and localized hyper-

thermia. Whole-body hyperthermia is employed to arrest widespread malignant disease, metastases and the primary tumour by a few degrees total body temperature elevation. This can be achieved by the immersion of the patient in a water bath or wax bath. However, the method of using a water bath has certain disadvantages, one of the most important being the discomfort caused to the patient, in addition to the loss of fluid and electrolytes. The latter problem can be solved, to some extent, by employing a wax bath instead of a water bath. In patients with advanced and widespread malignancies, applying systemic hyperthermia by making the patients breathe oxygen-enriched hot air while being immersed in a wax bath, Pettigrew (1974) in Scotland, reported tumour regression and significant palliation in most cases, though no long-term cure could be obtained.

Local heating appears to be a more acceptable and convenient method for confined tumours, especially of the surface. Several methods using water bath, microwave, ultrasound and heating induced through electrodes, etc., are being tried in different laboratories to achieve controlled high temperatures. Water bath heating may be feasible only for tumours of the extremities. For deep-seated growths other methods of heating have to be used. The main problem in these cases is the control of temperature so that uniform heating of the tissue without overheating of the surrounding normal areas can be achieved. So far, the best method conceived is that of microwave heating combined with deep-penetrating X- or gamma rays. The photon beams (X- and gamma rays) will ensure uniform irradiation of the malignant tissues. At present several centres in USA, Japan and many European countries are using microwave hyperthermia along with radiation for cancer treatment.

Improved rates of tumour control and cure have been reported consistently by investigators by using hyperthermia with radiotherapy. However, there is no clear evidence to show that tumour cells are inherently more heat sensitive than normal cells. But certain conditions, both physiological

and environmental, make the former more susceptible to heat killing.

Hypoxic cells are approximately three times more radioresistant than oxygenated cells, and the relative abundance of hypoxic cells within a tumour is a major factor determining the radiation necessary for tumour control. Hypoxic cells have been shown to be more heat sensitive than normoxic cells. Thus by combining radiation with heat the cells which escape radiation death can be dealt with. As the number of hypoxic cells increases with the size of the tumour, combination therapy has a definite advantage over radiotherapy alone. This will also help in reducing the radiation dose needed to destroy the tumour, which in the absence of heat, would be prohibitively high.

The differential sensitization of the tumours is further influenced by its nature of blood supply. It has been found that *in vivo* the tumour micro-environment potentiates hyperthermia killing, which is due to a basic difference in the blood supply, in the tumour tissue blood supply is sluggish and vasculature primitive. Therefore, heat dissipation is poor, which leads to higher temperature in the tumour centre. This becomes more pronounced as the tumour volume increases.

The heat sensitivity is also affected by the cell cycle. The S-phase which is most radioresistant is also the most heat sensitive. This complementary relationship between hyperthermia and radiation permits the use of reduced doses of radiation for tumour control with a decreasing possibility of unacceptable normal tissue damage. Further, heat treatment results in a block of the cells at the G₂ phase (G₂' block), thus synchronizing the cells and accumulating them at a more radiosensitive stage. This can produce a synergistic effect of heat and radiation.

Cells in an acidic environment are shown to be more heat sensitive. Westermarck (1927) was the first to call attention to changes in tumour cell metabolism following hyperthermia. Later studies by different investigators in a number of *in vivo* and *in vitro* systems have shown a marked depression or inhibition of the oxidative

metabolism in heated tumour cells, whereas the anaerobic glycolysis was slightly depressed only after prolonged hyperthermic treatment. More evidence from recent literature (Overgaard, 1977) points out to anaerobic metabolism in tumour cells, while aerobic metabolism is preferred in normal cells. This results in the production of large amounts of lactic acid in the tumour, resulting in an acidic environment, rendering these cells more susceptible to heat killing.

Several temperatures ranging from 40°C to 45°C have been found to have cell inhibiting or killing effects. Heat killing increases with an increase in temperature. However, an optimum temperature of 42.0°C to 42.5°C has been suggested for application in humans as temperatures below 41.5°C are insufficient and those above 43°C may have cytotoxic effects. At high temperatures undesirable side effects like cardiac disturbances and intravascular coagulation have been reported. Within 41.5°C to 43.5°C, a 1°C rise doubles the thermal killing effect. As far as radiosensitization is concerned, a temperature of 42.0°C to 42.5°C is desirable. Thermosensitization to the lower range of hyperthermia, 40°C-41°C, can be increased by a short priming with a higher temperature; 45°C for 5 min-10 min followed by 40°C or 41°C for 2 hours has the desired effect.

Time of application. Simultaneous radiation and heat application is found to yield the best results, even though this is very difficult to perform in human patients. Post-irradiation heating has its advantages if given with 4-6 hours after exposure; heat causes breaks in cells and inhibition of repair of sublethal (SLD) and potentially lethal damage (PLD). But the effect varies with the type of malignancy. Heat treatment inhibits entry of cells into mitosis by G₂ block and also increases the number of acentric chromosome fragments. The use of heat after irradiation in fractionated radiotherapy can be advantageous in inhibiting cell recovery during the interval between the fractions. But in such cases, the development of thermo-tolerance can be a disadvantage, especially when the fractions are closely spaced as in

multiple daily fractions. Another problem which may be encountered is the different types of response by the different types of malignancies to the combined treatment. It has been observed in some *in vitro* systems that those cell lines with a higher capacity of SLD repair are more sensitive to heat killing as their repair capacity is greatly impaired by thermal treatment. Hyperthermia influences the radiation response mainly by:

- (1) decreased repair of sublethal damage,
- (2) Increased lethal damage,
- (3) sensitization of cells in relatively radioresistant phases of the cell cycle,
- (4) sensitization of hypoxic cells, and
- (5) inhibition of repair of potentially lethal damage.

In addition, the development of lysosomes during the first few hours of heat treatment has been reported; tumour cell lysosomes are more heat labile than those of the normal cells (Overgaard, 1977). Malignant cells also develop a heat induced respiratory depression, which is not found in normal cells.

In clinical application proper care has to be taken to avoid overheating of normal cells and to maintain proper temperature control. Above 42°C, physiological disturbances like cardiac disturbances, liver dysfunction, cerebral derangement and water and electrolyte loss have been reported. While daily multifraction treatments are planned, the major consideration should account for any thermo-tolerance that may develop. With proper planning and temperature control, heat can act as an effective adjunct to radiotherapy of cancer.

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NMR in diagnosis

THE 1950's saw the birth of Nuclear Magnetic Resonance (NMR) spectroscopy which ushered in a new era in scientific research. NMR spectroscopy was discovered by Felix Bloch of Stanford University and Edward M. Purcell of Harvard University for which they jointly shared a Nobel Prize in 1952.

The discovery of x-rays had made it possible to take snapshots of the organs inside a human body. However, x-rays are not advisable frequently because they cause physiological damage.

Recently, a breakthrough was achieved in x-ray technology with the introduction of x-ray computerized

tomography, referred to in short as CT. By this technique, x-ray data of a particular region of the body are taken from different angles. The computer then reconstructs the data to give cross-sectional views of the region under study. CT scanning, though an important tool in modern medicine, however, cannot differentiate between healthy and diseased tissues. This is exactly where NMR techniques are expected to work in the near future. NMR instruments designed to take pictures of the inside of a human body would not only provide a clear picture of the organs, but would also distinguish between healthy and unhealthy tissues thereby quick-

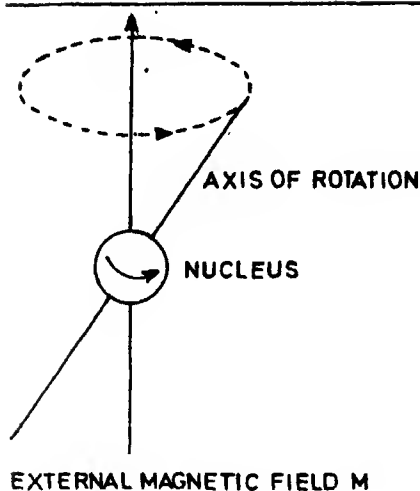


Fig.1. Precessional motion of nucleus

ening and simplifying diagnosis. Apart from others, it would be a boon for cancer patients, for cancer detection would become not only quicker and simpler, but the cancerous spots would be pinpointed. Unlike x-rays, NMR would not leave behind any harmful side effects.

Upto now, NMR has been primarily used to elucidate complicated structures of organic molecules by measuring in particular, resonances of hydrogen nuclei or proton. It is this concept that is being made use of medically also. NMR is being used to distinguish between the intricate structures of organic molecules that constitute organs of a body. Biological molecules comprising human body contain hydrogen. These biomolecules get affected with disease. Therefore, differences in the resonating hydrogen nuclei in the biomolecules of healthy and unhealthy tissues would be the criteria to distinguish between them. Before proceeding any further, it would be worthwhile to throw some light on the concept of NMR.

Theory of NMR

All of us know that an atom consists of a nucleus with electrons circulating around it. The nucleus of an atom spins about its axis. The nucleus is a charged body, and therefore, when it spins about its axis, it gives rise to a magnetic field with magnetic moment μ directed along the axis of spin. If the nucleus is placed in an external

magnetic field M , the magnetic field would try to bring the axis of rotation of the nucleus parallel to itself. This causes the nucleus to make a precessional motion (Fig.1) like that of a spinning top.

When the proton is placed in an external magnetic field M , it takes up two orientations (arrangements); it can be parallel (low energy state) or antiparallel (high energy state) to the direction of the external magnetic field. The proton can be made to flip from the lower energy state to the higher one by the application of an electro-magnetic radiation, at right angles to the magnetic field M . The electro-magnetic radiation required falls in the radio-frequency (rf) region. The rf radiation is supplied by an oscillator whose magnetic field is at right angles to the applied magnetic field M (Fig.2).

The nucleus, on being promoted to the higher energy state, cannot stay there indefinitely. It comes down to the lower energy state and gives out energy in the form of radiation which is measured. This phenomenon is known as nuclear magnetic resonance (NMR).

An important question facing us is whether all nuclei absorb at the same frequency. The answer is no; as then the NMR spectrum which is a plot of NMR signal vs frequency would consist of only one absorption line no matter what the organic compound is and hence taking an NMR spectrum would be meaningless. Different nuclei absorb at different frequencies because of the electrons circulating around the nucleus. The circulating electron gives rise to a field whose direction opposes the external magnetic field.

Different nuclei experience different magnetic fields depending on their electronic environment and in consequence absorb and give out energy at different frequencies. The separation of a resonance frequency from the chosen standard TMS (tetramethyl silane) is called chemical shift.

An important part of NMR instrumentation is the magnet. It is a known fact that NMR signals get distorted according to the shape and size of the sample if the magnetic field M produced by the magnet is not uniform.

The amount of distortion depends directly on the non-uniformity of the field and also on the amount of the sample exposed to the non-uniform parts of the field.

NMR picturising

Upto now, the quest has been to make magnets of the maximum possible homogenous field so as to get a clear spectrum of the sample. This property of the magnet undergoes modification when an NMR image and not spectrum of the sample is to be taken. The modification required is a non-uniform magnetic field. In such instruments, because of the non-uniform magnetic field, the instruments are not able to differentiate between the chemical shifts of different protons and hence a spectrum is not possible. It was the work of Paul C. Lauterbur of the State University of New York at Stony Brook that laid the foundation stone of using NMR like x-rays in 1973.

If a sample of say chloroform (CHCl_3) in a capillary tube is placed in a homogenous or uniform magnetic field M , the NMR spectrum will show a single narrow line for the resonating hydrogen nuclei in CHCl_3 . This line will remain unaffected by the shape of the sample so long as the magnetic field is uniform. If the magnetic field is made non-uniform then the resonating hydrogen nuclei in CHCl_3 will face different magnetic

(Continued on page 679)

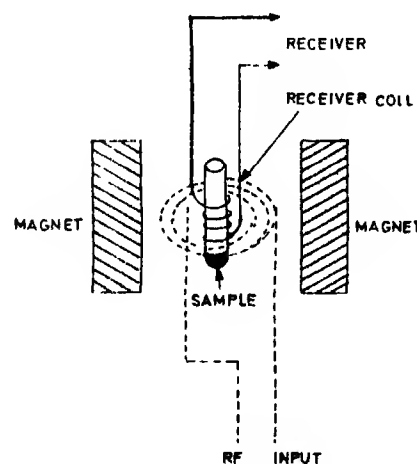


Fig.2



SCIENCE FOR THE YOUNG

Water in human body

WHAT is the most important inorganic component of human body? It is water, of course. The total body water constitutes 60% to 70% of adult body weight; the values are somewhat lower in women than in men and decrease with increase in age.

The total body water is distributed into two main compartments; water within cells (intracellular fluid) and water outside cells (extra-cellular fluid). The intracellular and extra-cellular spaces or compartments contribute about 50% and 20% of the body weight respectively. The extra-cellular fluid is further divided into (a) plasma water or inter-vascular fluid (water circulating in the blood vessels constituting 5% of the body weight), and (b) interstitial fluid (water as extra-cellular fluid present outside the blood vessels constituting 15% of the body weight).

The body water is of utmost physiological importance and has specific functions to perform: (1) it acts as a solvent for the secretory and excretory products; (2) acts as a carrier of nutritive elements to tissues and removes waste materials from them; (3) water is a solvent for electrolytes. It helps to regulate electrolyte balance of the body and maintain a healthy equilibrium of osmotic pressure exerted by solutes dissolved in water. A state of good health is possible as long as the osmotic pressure exerted by the solutes remain constant; and (4) it is a regulator of body temperature, evaporation is the main way of conducting heat to outside

and of dissipating it. The latent heat of evaporation of water is high, so the loss of a small amount of water in evaporated sweat means a relatively greater loss of heat.

Water is more important than food. Deprivation of water brings about death much more quickly than that of food. Loss of about 10% of body water causes illness and a further loss of about 10% may cause death. On the other hand, if water is given but food is not, the individual may survive for several weeks by utilizing the body fat and 50% of the tissue protein. Sometimes too much water is lost from the body, such as in the case of diarrhoea accompanied by vomiting leading to dehydration. If not controlled immediately, it may lead to death. It is controlled by giving water with salt orally or glucose solution parenterally.

The body possesses a relatively limited supply of water. Excessive fluctuations in water content must be avoided, i.e., the body water level is well balanced. A healthy body main-

tains water balance precisely. The chief physiological mechanism which prevents excessive loss of body water excretion is the action of antidiuretic hormone (ADH) or vasopressin, secreted by the posterior lobe of pituitary. A body is said to maintain water balance when the amount of water gained by the body is equal to the amount of water excreted or lost from the body. This may be explained as in Table 1.

Water is supplied to the body by the following sources: (1) Dietary liquids and solid food; water comprises 70%-90% of the weight of the average diet of adults. Every solid food consists largely of water; (2) Oxidation of organic foodstuff. Water is formed during combustion of proteins, fats and carbohydrates in the body. Quantities of water produced by oxidation of 1 gm of proteins, fats and carbohydrates are 0.34 ml, 1.07 ml and 0.56 ml respectively. Generally 10 ml to 15 ml of water is formed per 100 calories of energy produced in the body.

Water is removed from the body as follows: (1) Urine: It is an important form of elimination of water from the body. Daily excretion of urine is about 1 to 2 litres; (2) Faeces: About 80ml-150ml of water is excreted daily in the faeces of normal adults; (3) Perspiration: When environmental temperature or humidity increases, the sweat glands become active. Sweating removes a considerable amount of water from body. However, the actual amount of water lost by this method varies enormously. During summer season, excessive water is lost as perspiration. So the body needs (demands) more water in that

Table 1

Water intake in grams per day		Water output in grams per day	
Water intake as such	= 1100	Water excreted in urine	= 1000
Water intake in diet	= 900	Water excreted in stools	= 200
Water produced during metabolism	= 200	Water lost through skin and lungs	= 1000
Total intake	= 2200	Total output	= 2200

season; (4) Insensible perspiration: In this process the body loses water vapour continuously from the skin surface and lungs in inverse proportion to the relative humidity of the atmosphere. In the vapourization of 1ml of water, about 0.58 cal. is absorbed. This process contributes about 25% of the total heat loss

from body. Insensible perspiration eliminates about 850 ml of water per day from a 70 kg man.

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The useful vegetable gums

VEGETABLE gums are exuded when the bark of a tree is damaged and harden on exposure. Gums are composed of complex molecules of sugars and carboxy acids. They are divided into two groups according to their solubility in water: (a) soluble gums, which dissolve in water and form transparent viscous and adhesive solution, such as gum arabic, (b) insoluble gums, which when placed in water absorb it and swell into a thick jelly and form a thick translucent solution on further addition of water. They can be used as binders, thickeners, emulsifiers, stabilisers and film formers. They are useful in tablets subsuspensions, emulsions, jellies and a number of cosmetic preparations.

Sources

Plants that produce exudate gums are usually shrubs or low-growing trees. They grow best under tropical climatic conditions, mostly in the arid regions. Many trees yield gum in large quantities under adverse conditions, especially during dry season. Some of the historically important commercial exudate gums are gum ghatti (*Anogeissus latifolia* Wall.), gum karaya (*Sterculia urens* Roxb.), gum tragacanth (*Astragalus gummifer* Labill.), gum arabic [*Acacia senegal* (L.) Willd.] : All these commercially important exuded gums are obtained from several species of plants.

Gum tragacanth is the most important gum of commerce. It is obtained as dried gummy exudate from several species of *Astragalus*, the low bushy, perennial shrubs, having large taproots which along with the stems

and branches are tapped for gum. The gum consists of two portions, tragacanthin (30%-40%) and bassorin (60%-70%). Tragacanthin dissolves in

water forming a colloidal hydrosol, while bassorin swells in water to form a gel. The important physical properties of tragacanth are its ability to create extremely viscous solutions or gels with water; thickening and stabilising action; binding and adhesive ability; and film forming property.

Gum acacia is the oldest and most versatile of natural gums. It is the dried exudate obtained from the branches and stems of the plants belonging to the genus *Acacia*, most important of which is *Acacia senegal*.

Gum karaya is the dried exudation of the *Sterculia urens* tree. The principal growing area is India where the best quality gum is collected during



Fig.1. A—*Chickcrassia tabularis* Adr. Juss.; B—*Butea frondosa* Roxb.; C—*Sapindus trifoliatus* Linn.; D—*Feronia elephantum* Correa; E—*Acacia senegal* Willd.

April, May and June. Another Indian exudate gum is gum ghatti, which is an exudate of *Anogeissus latifolia*. Gum ghatti is also a very useful gum of commerce. Trees are tapped or blazed, and gum exudates are collected over a period of several days.

Many other trees of India also produce gums which are collected and often exported. The term "Indian" or "East Indian gums" encompasses many exudation products of oriental trees. Some of the important ones are: *Butea frondosa* Roxb. (Dhak or palas tree) furnishes a red gum known as "Bengal" or Palas kino, or "Butea gum". *Chickrasia tabularis* A. Juss. (Chitagong) produces amber gum. *Feronia elephantum* Corr. known as wood apple tree gives a yellow to reddish gum. *Melia azedarach* L. (China tree or China berry tree) is called pride of India and gives an amber-coloured gum. *Moringa pterygosperma* (Horse-radish tree) and *Terminalia* species furnish yellowish to reddish gums. *Anacardium occidentale* L., cultivated in India yields a reddish gum. *Sapindus trifoliatus* L. yields soap nut tree gum, locally known as "Ritha"

Uses

All gums form viscous solution or gels with water, and are utilized in industry in different ways. In the field of cosmetics and pharmacy hydrophilic colloids are used because of their property of soothing inflamed or abraded membrane of skin and protecting them from irritation. They are used as demulcents or emollients. In lotions, ointments, face creams and other cosmetic preparations, they are used as suspending and emulsifying agents.

In recent years, after much development work, hydrophilic colloids and modified celluloses have found use in the paint industry in place of casein. The colloids used are alginic acid and its sodium and ammonium salts and modified celluloses are sodium carboxymethylcellulose and hydroxyethylcellulose. In these uses they serve as thickeners. As film formers with no modifying agents added, their use in paints is limited to a few special items. Gum arabic has been employed in paints as a glaze

and for emulsifying oils. Other kinds of protective coatings also include natural gums in their composition.

Gums are widely used in the food industry. Gum arabic is employed in confectionary to prevent crystallization of sugar. It is used as a glaze in candy products and as a component in chewing gums, cough drops and candy lozenges. It has an extensive application as a stabilizer in frozen food products. It is also used in

baking industry for its viscosity and adhesive properties.

Natural gums have many uses in the textile industry. Starch and dextrans find wide use and frequently gums are used as a supplement to starch, chiefly to toughen the starch film. They are used mainly as thickeners and as sizing agents.

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Prime and decomposed magic squares

STUDY of magic squares can be a source of fascinating amusement. Indeed magic squares can provide hours of fun and rewarding distraction to any recreational puzzle enthusiast. Thousands of magic squares of rare quality with many unusual and unique characteristics have been constructed by maths puzzlists. We intend to present in this article two unusual types of magic squares called prime and decomposed magic squares which are not so common and exhibit interesting properties too.

Prime squares

Construction of magic squares using prime numbers is an intricate problem indeed. The lowest order prime square that can be constructed is a 3×3 square (Fig.1). This square has the magic constant 177. However, the numbers involved in the construction of this square do not belong to any definite sequence or series.

71	89	17
5	59	113
101	29	47

Fig.1

Prime squares with numbers forming a definite sequence or series can also be constructed. An order-3 prime square can be developed, for instance, using the sequence of primes 199, 409, 619, 829, 1039, 1249, 1459, 1669 and 1879 (Fig.2). These primes are in arithmetical progression on having a common difference of 210 between the consecutive terms. The magic constant of this square is 3117. The formula by which this magic constant can be calculated is

$$M = n \left[\frac{2A + (n^2 - 1)D}{2} \right]$$

where n stands for the order of square, A is the first term of the series and D is the common difference between the successive terms.

It is also possible to construct an order-4 prime square using an arithmetical sequence of primes. This sequence starts with 2, 236, 133, 941 and has a common difference of 223, 092, 870 between the consecutive terms; the last, i.e., the 16th term of

1669	199	1249
619	1039	1459
829	1879	409

Fig.2.

5582526991	2459226811	2682319681	4913248381
3128505421	4467062641	4243969771	3797784031
4020876901	3574691161	3351598291	4690155511
2905412551	5136341251	5359434121	2236133941

16	41	36	5	27	62	55	18
26	63	54	19	13	44	33	8
1	40	45	12	22	51	58	31
23	50	59	30	4	37	46	9
38	3	10	47	49	24	29	60
52	21	32	57	39	2	11	46
43	14	7	34	64	25	20	53
61	28	17	56	42	15	6	35

Fig 4

the sequence is 5, 582, 526, 991. This prime square (Fig.3) has a significantly large magic constant of 15, 637, 321, 864.

Prime squares of 5th and higher orders seem to be an impossibility at present; for the existence of a prime series with terms more than sixteen remains till to date an unsolved problem.

Decomposed magic squares

A square can be magic not only for addition but also when its individual elements are squared and then added. Such magic squares are called doubly magic squares. An 8th order doubly magic square is shown in Fig.4. This magic square can, interestingly, be decomposed into two magic squares x and y (Figs.5 & 6) such that the square of the magic constant of the original (doubly magic) square is the sum of the squares of the magic constants of the squares x and y. The magic squares x and y have constant of 156 and 208 respectively whereas the magic constant of the original square is 260 so that

$$156^2 + 208^2 = 67600 = 260^2$$

Interesting relations exist among the elements of these squares. The square of any element of the original square is the sum of the squares of the corresponding elements of the squares x and y. Thus

x
Fig 5

9 · 6	24 · 6	21 · 6	3	16 · 2	37 · 2	33	10 · 8
15 · 6	37 · 8	32 · 4	11 · 4	7 · 8	26 · 4	19 · 8	4 · 8
0 · 6	24	27	7 · 2	13 · 2	30 · 6	34 · 8	18 · 6
13 · 8	30	35 · 4	18	2 · 4	22 · 2	28 · 8	5 · 4
22 · 8	1 · 8	6	28 · 2	29 · 4	14 · 4	17 · 4	36
31 · 2	12 · 6	19 · 2	34 · 2	23 · 4	1 · 2	6 · 6	27 · 6
25 · 8	8 · 4	4 · 2	20 · 4	38 · 4	15	12	31 · 8
36 · 6	16 · 8	10 · 2	33 · 6	25 · 2	9	3 · 6	21

SCIENCE FOR THE YOUNG

12.8	32.8	28.8	4	21.6	49.6	44	14.4
20.8	50.4	43.2	15.2	10.4	35.2	26.4	6.4
0.8	32	36	9.6	17.6	40.8	46.4	24.8
18.4	40	47.2	24	3.2	29.6	38.4	7.2
30.4	2.4	8	37.6	39.2	19.2	23.2	48
41.6	16.8	25.6	45.6	31.2	1.6	8.8	36.8
34.4	11.2	5.6	27.2	51.2	20	16	42.4
48.8	22.4	13.6	44.8	33.6	12	4.8	28

Y

Fig. 6.

$$(24.6)^2 + (32.8)^2 = 1681 = 41^2$$

$$(34.8)^2 + (46.4)^2 = 3364 = 58^2$$

$$(16.2)^2 + (21.6)^2 = 729 = 27^2$$

..... and so on.

Further, the mean of the same two elements of the original square and the square x is seen to be the same as

the corresponding elements of the square y

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Science quiz (Nobel Prizes)

1. In which year and in which fields was the Nobel Prize for the first time Instituted?

- (a) 1983; Physics, Chemistry Medicine or Physiology, World Peace and Literature.
- (b) 1901; Physics, Chemistry, Medicine or Physiology, World Peace and Literature.
- (c) 1896; Geology, Physics, Chemistry, World Peace and Literature.
- (d) 1833; Physics, Chemistry, Medi-

cine or Physiology, World Peace and Literature.

2. The amount left over by Alfred Nobel as assets for the award of prizes is

- (a) \$9 millions (b) \$10.2 millions
- (c) \$20.6 millions (d) \$9.2 millions

3. The place where Nobel passed away on 10th December 1896?

- (a) San Remo (Italy) (b) Paris (France) (c) Stockholm (Sweden) Leningrad (Russia)

4. Among the four institutes to award the Nobel Prizes, the one which awards the Nobel Prize in Chemistry and Physics is

- (a) The Swedish Academy (b) Norwegian Parliament (c) Royal Caroline Medico-Surgical Institute (d) Sweden's Royal Academy of Sciences

5. The place where the Nobel Prizes are presented?

- (a) San Remo (Italy) (b) Stockholm (Sweden) (c) Leningrad (Russia) (d) Paris (France)

6. At present how much amount is awarded to a Nobel laureate?

- (a) \$180,000 (b) \$100,000 (c) \$42,000 (d) \$200,000

7. Who received the Nobel Prizes both in Physics and Chemistry?

- (a) Marie Curie (Marie Sklodowski) (1903-1911)
- (b) John Bardeen (1956, 1972)
- (c) Linus Pauling (1954, 1962)
- (d) Pierre Curie (1903, 1935)

8. Which country has bagged the maximum number of Nobel Prize till now?

- (a) USA (b) Great Britain (c) Germany (d) France

9. Upto now how many Indians have received this coveted prize?

- (a) Three (b) Five (c) Four (d) Two

10. Indian born scientist Prof. S Chandrasekhar received 1983 Nobel Prize for his work in one of the following fields

- (a) Molecular Biophysics (b) Solid State Physics (c) Liquid State Physics (d) Astrophysics

11. Upto now how many parent child pairs have received this prize?

12. At present who is trying to become fourth pair and the first grand pair (Grandson-Son-Father)

- (a) Karl Manne Georg Siegbalm (b) Kai Siegbalm (c) Nil Siegbalm (d) Irene Joliot Curie

13. Who was the first Nobel Prize winning pair?

- (a) Sir William Henry Bragg and William Lawrence Bragg
- (b) Irene Joliot Curie and Marie Curie
- (c) Pierre Curie and Marie Curie
- (d) Karl Manne Georg Siegbalm and Kai Siegbalm

14. How many couples have received the Nobel Prizes?

(a) Two (b) Three (c) Four (d) One

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Answers:

(1) b, (2) d, (3) a, (4) d, (5) b, (6) d,
(7) a, (8) a, (9) a, (10) d, (11) a, (12) c,
(13) a, (14) a

FOR HER (Continued from page 682)

heaps for about 12 hrs and be dried slowly. The tea thus obtained contains less tannins and more theine hence makes better tea.

Q.6. Malt is good for children.

Ans. Germinated barley is called malt. It forms a useful food for delicate children because the enzyme diastase it contains helps in the digestion of starch.

Q.7. Young potatoes are not so good as nutrients.

Ans. Potatoes are easily digested when fully grown and properly

cooked. Young ones are composed of immature cell tissues and unformed starch and hence are indigestible and less nutritious. The useful nutrients in potatoes are starch and salts—malates, tartrates and citrates.

Q.8. French coffee is inferior to pure coffee.

Ans. French coffee contains 60%-75% of chicory which means it is 60%-75% adulterated as against pure coffee.

Q.9. When milk is boiled, a skinny layer settles on top.

Ans. This is nothing but coagulated milk albumin.

Q.10 Silk is an animal product.

Ans. Silk is a kind of gelatinous secretion which the silk worm covers itself with, when it is about to change from a silk-worm to a moth. This substance hardens on exposure to the air and forms silk thread.

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MEDICAL NOTES (Continued from page 673)

fields at different parts of the sample. In consequence the spectrum will no longer show a single sharp line, but would give a broadened plot. The magnetic field is made non-uniform by applying another linear magnetic field gradient M_1 parallel to the magnetic field M .

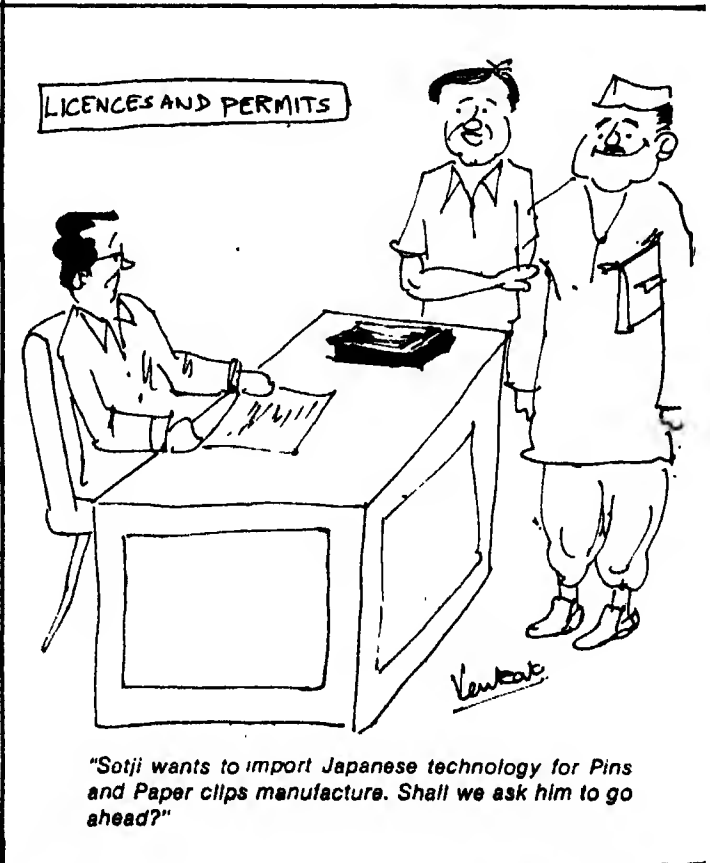
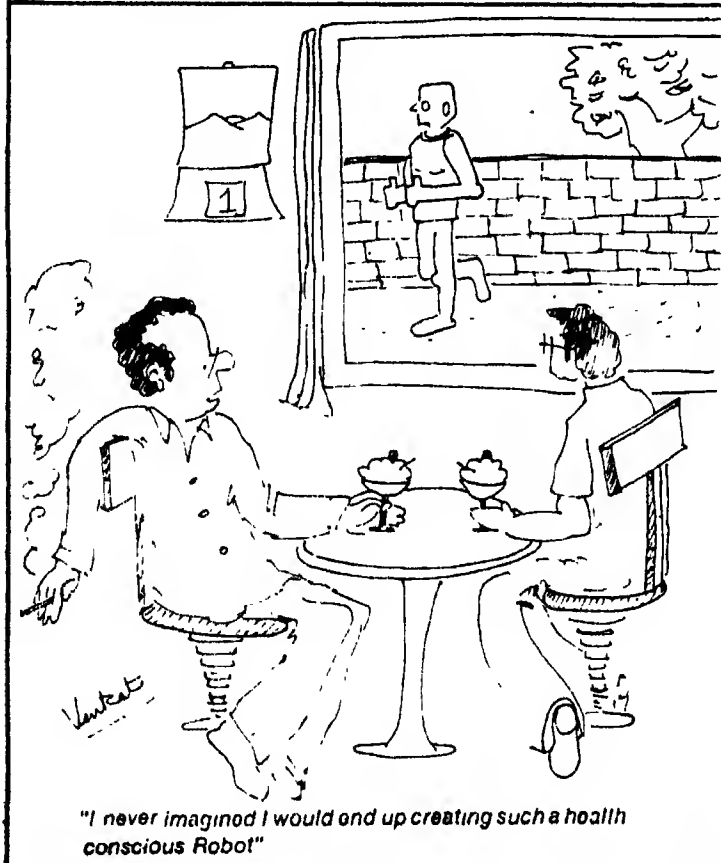
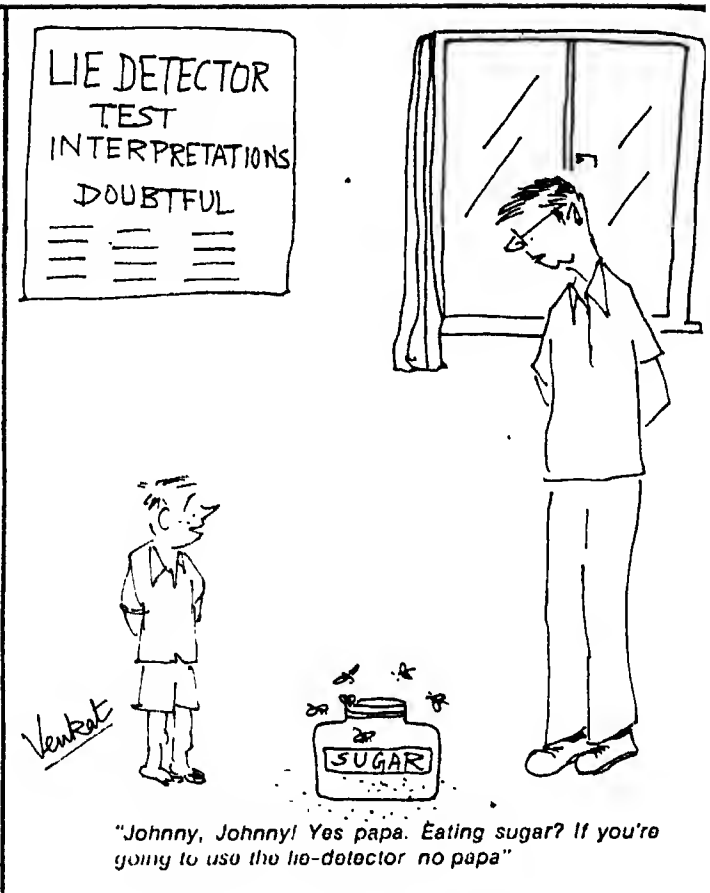
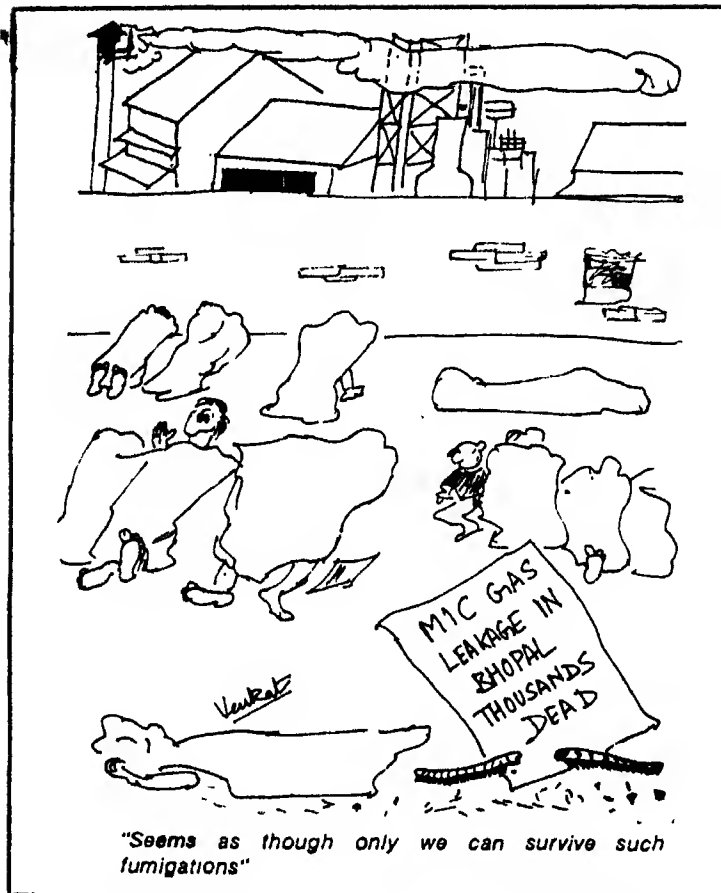
If the linear magnetic field M_1 is rotated electronically, such broadened plots or projections of the sample from different angles can be obtained. Computer analysis of a number of such plots reconstructs the image of the sample.

Though the technique of the clinical

use of NMR is still in its prime, with the rapid strides in research we can look forward to it taking the shape of a powerful diagnostic tool in the near future.

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FOR HER

Pimples mar beauty

PIMPLES, blackheads, nodules and moles are a major problem among adolescents. They not only mar their beauty but also create an inferiority complex among them. The frequency of pimples is quite high in adults. What are they and what is the cause of pimples during adolescence?

Types of pimples

Pimples, in general, are crops of small, whitish or reddish lumps on the skin of the face, chest and back which are usually accompanied by an oily skin. The little lumps contain clumps of thickened oily secretion from the sebaceous glands or sweat glands and also pus when injected. They are of following types.

(i) *Acne*. Acne is a condition in which inflammation and infection of the sebaceous (oil) glands and ducts lead to pimples, pustles and cysts on the surface of the skin. Acne is most likely to appear on those parts of the body which have the most numerous glands, particularly around nose, on cheeks and shoulders.

(ii) *Blackhead*. Blackhead is a plug of dried, waxy material in a sebaceous skin oil gland, especially on face. Its exposed end is blackened by soot or grime. The dark colour of the characteristic blackheads is also due to the discolouring effect of air on the fatty substance in the clogged pore. The pimple is known as white-

head when it has not been turned black by air. Blackheads are common in acne.

(iii) *Comedones*. Comedones are plugs of dried, cheesy secretion of the oil glands of the skin formed when they get clogged. They are common in adolescent acne.

(iv) *Rosacea*. Rosacea is a skin condition characterised by redness of the nose which may spread to the forehead and neck. This is followed by appearance of small, dilated (expanded) blood vessels. Tiny pimples develop on the flushed areas. These pimples are more superficial than acne pimples and do not leave scars. Rush of blood to the affected area is a nervous reflex, stimulated often by alcohol and also by highly spicy foods. The condition is sometimes called "whisky nose", an unfair name because many people who develop rosacea never had an alcoholic drink. Rosacea can also affect eyelids and lead to superficial keratitis, a painful inflammation of the cornea which should be treated by an ophthalmologist.

(v) *Mole*. Mole is a permanent, small dark mark on the human skin. This is completely different from pimples in that it is caused by oil glands. This may sometimes lead to the growth of a benign tumour on the body.

Causes of pimples

(a) *Clogging of sebaceous glands*. Beneath the skin there are numer-

ous, minute oil glands called sebaceous glands. They produce small quantities of oil or "sebum" to keep skin soft, greasy and smooth. The glands are associated with upper part of hair follicle by a small duct. Oil comes on to the skin through tiny pores and prevents skin from becoming wet by water. Sometimes these pores get clogged with wastes from skin cells and dirt of air. A swelling results as the oil cannot come out. Moreover, when any part of the body is blocked by a foreign material, White Blood Corpuscles (WBC) come and encircle the dirty foreign substance. Gradually the WBCs are turned into dead cells and form pus around the gland. A pimple is so produced. When a pimple is squeezed, a whitish fluid (pus) comes out along with a dense, rounded nucleus around which pus formation takes place.

(b) *Sex hormones*. During puberty, the pituitary governor of endocrine activity alters the proportion of male sex hormone "androgen" and female sex hormone "estrogen" for maturation of sex. Both boys and girls have a consistently high level of respective sex hormones between puberty and maturity. This increase in sex hormones activates production of sebaceous glands which usually discharge sebum through pores for lubricating the skin. Overproduction of sebum causes it to turn into a paste which backs and plugs up ducts extending from glands underlying derma through layers of epidermis (Fig.1)

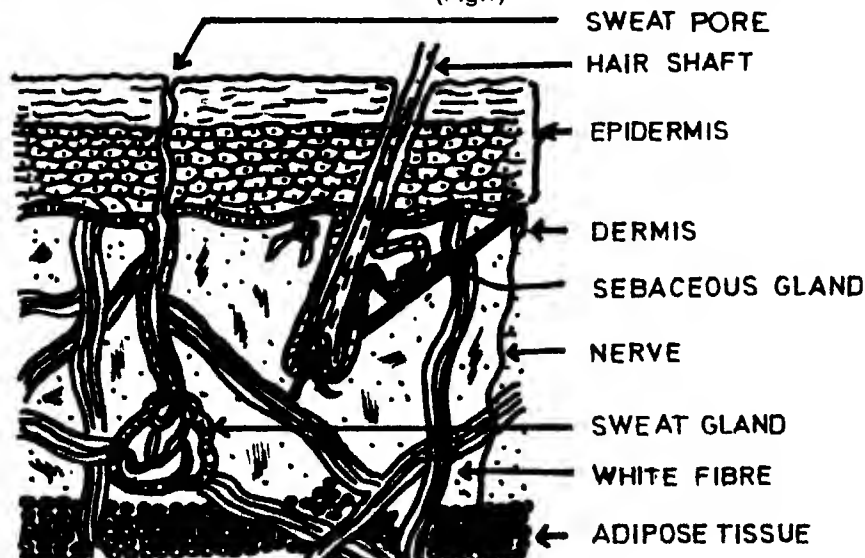


Fig. 1

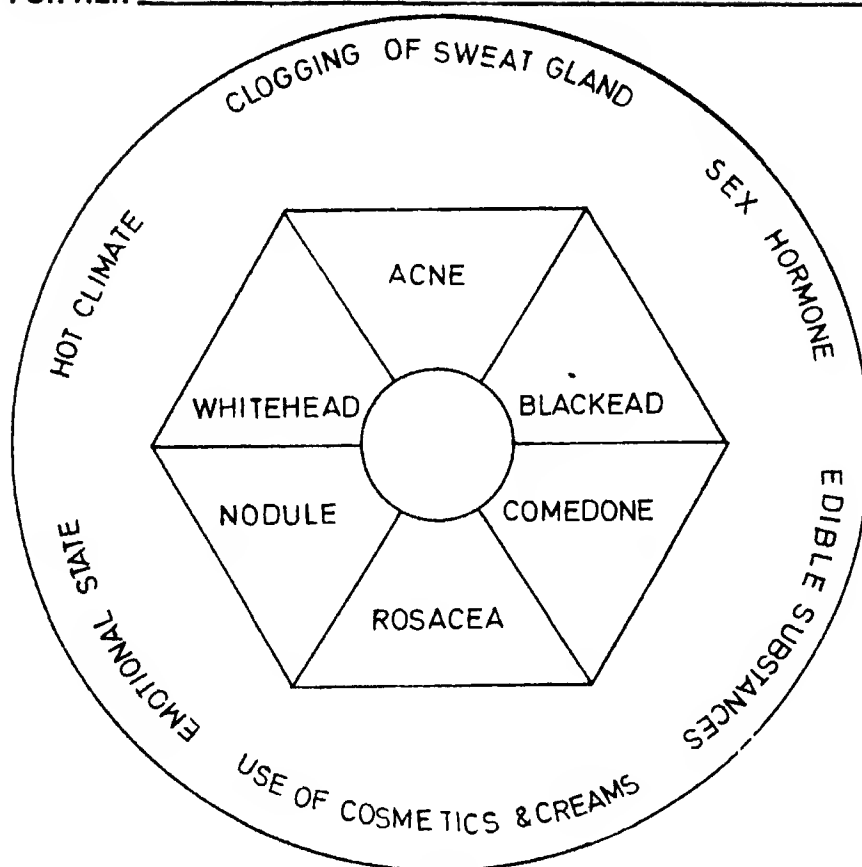


Fig.2

(c) *Edible substances and drinks*
Some foods seem to intensify attacks of acne. They include chocolate, iodized salt, sea food containing iodine, fats and fried foods, dairy products, seasoned food material, etc. Besides, drinks like alcohol, coffee and tea also trigger off development of pimples.

(d) *Cosmetics*. As skin pores are minute and often clogged by dirt or cosmetics or various types of creams, the fatty sebum accumulates under the skin and forms a pimple.

(e) *Other causes*. Apart from these reasons, emotional states and hot climatic conditions also stimulate production of excess oil, causing formation of acne.

Preventive measures

What can be done to get rid of pimples? In a majority of cases, acne is a transitory condition that gradually diminishes with the stabilization of hormones during adulthood. People with oily skin are more likely to develop pimples, blackheads, etc., than those with less oily skin. Therefore, in its mild form, it can usually be

controlled by cleanliness and avoidance of rich desserts, fried foods and beverages. Thirdly, creams and cosmetics that further clog pores should be avoided in favour of medicated soaps and hot water. Sulphur and resorcinol are useful local applications for good results in both sexes.

Besides, use of cleansing pads containing an astringent lotion (a substance that shrinks soft tissue and contracts blood vessels checking the blood flow) is a helpful counter measure.

One important point is that during the onset of pimples, they should not be squeezed. This method of elimination of pus can lead to more serious infection. In fact, squeezing usually drives as much oil back deeper into skin as it removes and hence the inflamed area is enlarged. Sometimes, squeezing also leads to bacterial infection and causes cyst formation that damages the underlying dermal tissues. Squeezing should be completely avoided.

Conclusion

Adolescents are especially sensitive about their appearance and should not be teased about their pimples. Youngsters or teenagers should keep in their minds that acne or pimples are only a temporary condition which would not mar the beauty by proper care, precaution and prevention.

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Understanding why ?

Q.1. When a vegetable oil is heated at a high temperature, why does it smell and why do our eyes burn with fumes?

Ans. Because a poisonous, bad smelling gas called acrolein is generated due to the decomposition of oil.

Q.2. When kept cold, milk does not sour.

Ans. Souring microbes called *Streptococcus lacticus* do not grow below 9°C.

Q.3. Eggs do not form a perfect food, although they contain everything that is needed for growth of body of the chick.

Ans. Eggs are deficient in carbohydrates and various salts.

Q.4. Vinegar is used as a preservative.

Ans. Vinegar is 5% acetic acid solution. Microbes do not survive at acidic pH and also the hard vegetable fibres and cellulose of green vegetables turn soft in vinegar.

Q.5. Black tea leaves make better tea.

Ans. The smaller the tea leaves, the better is the quality. If dried over wood fire while still fresh, the green colour is retained. For black tea, the tea must lie in

(Continued on page 679)



Automatic pH control system for sugar industry

UNDER a grants-in-aid project of the Electronics Commission, the Central Electronics Engineering Research Institute (CEERI), Pilani, developed in the first phase a digital dual set point pH control system in which lime addition was controlled in an 'on off' manner for the juice clarification stage in sugar industry. About 38 such systems have already been installed and are in operation in various sugar factories in the country.

Subsequently, CEERI has developed an advanced control system—Microprocessor-based Automatic pH Control System (MAPCON)—for the juice clarification process. MAPCON continuously monitors and controls the pH at three different places in the reaction vessel by controlling the flow of lime at two places and flow of sulphur dioxide at the third place. It has three independent digital PID control loops, integrated completely with indigenously designed motorized valves for on-line control of lime and SO_2 simultaneously. It is for the first time in the country that SO_2 can be continuously and automatically controlled on-line in the juice clarification process while the excess SO_2 is diverted to the syrup sulphitation vessel installed adjacent to the juice sulphitation vessel. The system automatically takes care of any fluctuations in the crushing rate, juice flow, lime baume, SO_2 concentration, etc.,

while maintaining pH closely around the set values.

Alarm conditions are indicated by means of flashing current value of the display if it goes beyond the set limits. This draws the attention of the operator immediately to any malfunction, like stoppage or substantial drop in the flow of juice, lime, SO_2 , etc.

MAPCON has undergone successful field trials in a commercial sugar factory in Uttar Pradesh near Delhi during the 1983-84 crushing season and has received users' appreciation and acceptance reports. Besides meeting the primary objective of maintaining pH within ± 0.15 of the set values, it improves settling rate and raises purity with reduction in CaO content in the clear juice.

MAPCON basically consists of a conventional pH electrode system connected to a pH transmitter. Three such units acquire the process pH values which are to be controlled. The acquired data is displayed on 3½-digit digital panel meters which are 'bus' organized and interfaced to a 8085 based microcomputer. Three stepper motor driven valves, two for controlling flow of lime and one for controlling SO_2 , are also interfaced to the microcomputer through three-stepper motor drivers. The dynamic valve position is indicated on a corresponding bar-graph display. The microcomputer is programmed to control the three measured parameters through the three valves using PID algorithms (software). The PID constants and the set-points for each control loop are pre-selected and entered through a keyboard.

Mica-based textured coating

THE Central Glass & Ceramic Research Institute (CGCRI), Calcutta, has developed, for the first time in India, a process for the production of mica-based textured coating. The coating can be used both for protection and decoration of exterior surfaces. It is ideal for glass reinforced gypsum surfaces and also for metallic, concrete, masonry and wooden surfaces. It is particularly useful for

the protection and decoration of exterior surfaces of commercial buildings, industrial plants and domestic houses. It is more economical and durable than the conventional points, and, being highly flexible, withstands normal contraction and expansion of buildings. It forms an attractive textured surface which can be given different shades. It can be simply sprayed with an ordinary spray gun, and has a covering capacity of 1-1.5m²/litre. It is based on waste mica and has the outstanding properties of fire resistance and insulation.

Construction of reinforced concrete pavement

THE Central Road Research Institute (CRR), New Delhi, has evolved a technique for the design and construction of continuously reinforced concrete pavement; the technique has been taken up by the Central Assessment Committee of the Ministry of Shipping and Transport as one of its sponsored techniques for adoption by the state road construction agencies.

Recently, the institute provided know-how of this technique and gave a demonstration of construction to the U.P.P.W.D., who have built a continuously reinforced concrete pavement of 270m length (dual lane) with elastic joints, laid on a section of Ghaziabad bypass. The provision of elastic joints enables reduction in the quantity of steel (up to 50%) used in such constructions, and also prevents random cracking.

Unlike plain concrete pavements, the new pavements allow longer slab lengths without expansion joints, thus providing better riding quality and reduced maintenance. The reduced thickness needed in this type of construction results in an economy of 25% in the use of cement.

ENVIRONMENT

The river of sorrow

THE Damodar river originates from Chhotanagpur plateau in Bihar, flows along a course of about 500 km through Bihar and West Bengal and joins the Hooghly river opposite Falta at a distance of 58 km South of Calcutta. Barakar, Jamuria, Konar and Bokaro are its tributaries. The river carries a lot of eroded soil, pebbles, sand, etc., from Chhotanagpur area and causes silting problems in its lower valley region in West Bengal creating flood havoc during rainy season.

The river was known for a long time in West Bengal as "the river of sorrow", analogous to the Hoang Ho river of China. Devastating flood was

an annual event of the river in the lower valley in West Bengal, bringing in its trail loss of hundreds of lives and colossal damage to properties.

Ruhr of India and the Damodar river

In 1955 Durgapur barrage was set up under the auspices of Damodar Valley Corporation (established in 1948) to ensure all round improvement of the Damodar Valley through flood control, irrigation, waterways transport, power production, etc. Two main canals on the right and left banks of the river are used for irrigation in Burdwan, Bankura, Hooghly and Howrah. The creation of Durgapur barrage gave impetus to the

development of a chain of industries from 1960 onwards which led to the largest industrial complex in the eastern region from Durgapur to Asansol, known as the "Ruhr of India".

In its upstream course, the river, while passing through Bihar coal belt area, picks up wastes from Sindri Fertilizers (chromate, ammonia, naphthalenes) and Bokaro Thermal Power Units (flyash, oil, grease, etc.). The river gets an overdose of toxic chemicals and metals from industries in the lower valley in the 50 km stretch of Asansol-Durgapur industrial belt.

The river receives industrial pollutants through two storm water drains—Nunia Nalah in Asansol region and Tamla Nalah at 5 km beyond Durgapur—besides getting pollution dose through some drains from Indian Iron and Steel Co (Burnpur), Bengal Paper Mill (Raniganj) and Durgapur Steel Plant (Waria). Except at Durgapur barrage the river is thin and lean throughout the year excluding the monsoon season. Side by side, Tamla Nalah discharges larger volume of water throughout the year which presents a sharp con-

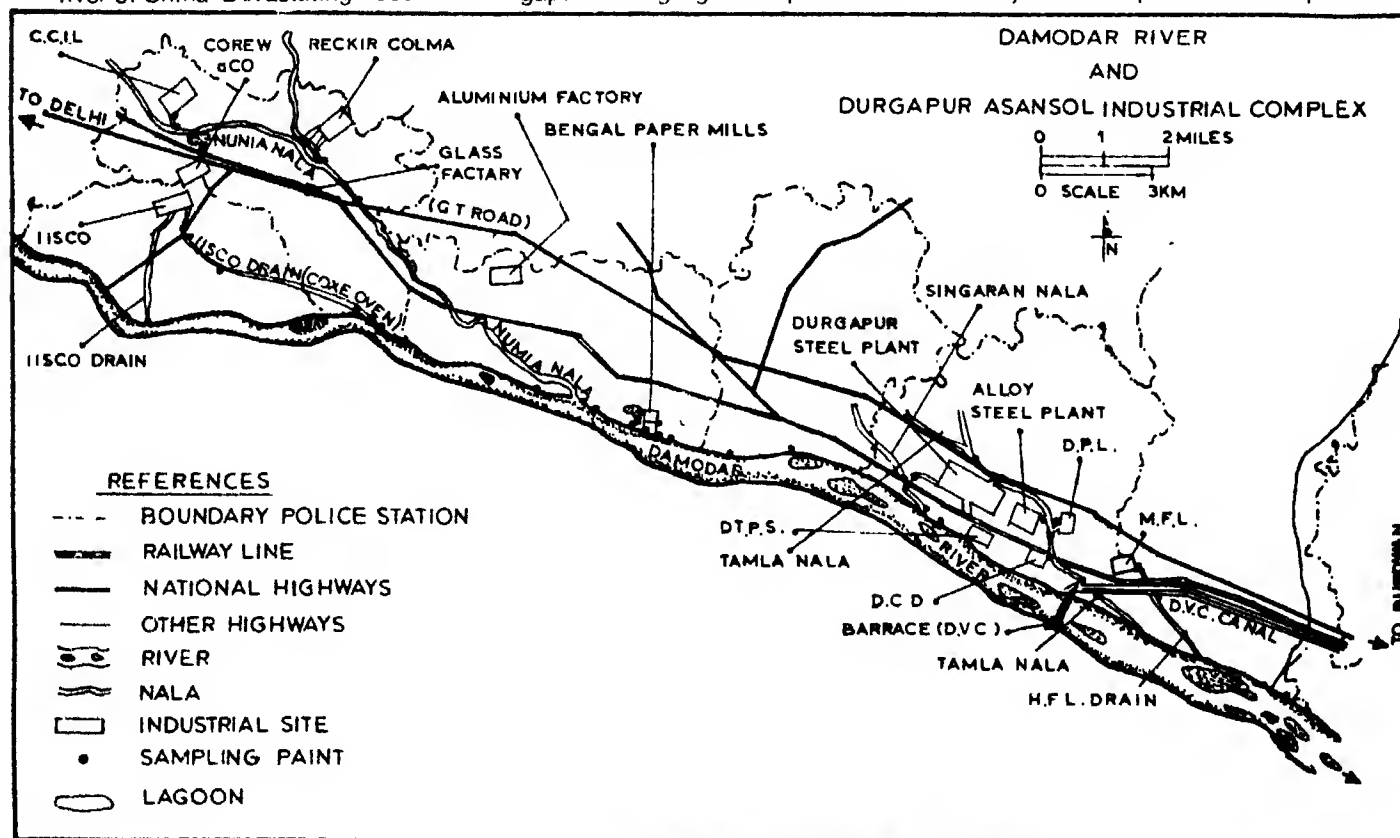


Fig.1. Damodar river and Durgapur—Asansol industrial complex

trast to the river particularly during summer. The river downstream gets polluted to the maximum extent during summer after receiving the pollution load from Tamla Nalah.

It should be noted that the barrage water is the source of water supply to Durgapur industries and townships for domestic and industrial purposes. There are water treatment plants at Durgapur Project Ltd. and Durgapur Steel Plant, but they employ conventional methods of sedimentation, sand filtration, alum treatment and chlorination. These methods, however, cannot remove pollutants like organic matter and toxic metals which will find their way to drinking water and cause health hazards.

Most of the industries causing public health concern are chemical industries almost all of which discharge their waste without any treatment. An idea about the huge loss of chemicals through drains can be obtained from two typical examples. One industry discharges daily about 3171 kg of ammonia, 181.2 kg of phenol, and 906 kg of benzene, toluene and solvent naphtha; another industry allows concentrated ammonia to evaporate in a 60,000 M₃ lagoon. One industry enforces strict security at the entrance gate but has open frontiers at the backside.

Pollution profile of Damodar river

The pollution loading at different points of Damodar river will now be examined. The concentrations of the parameters are expressed in parts per million (ppm).

At Burnpur the river picks up ammonia (47 ppm-60 ppm), nitrate + nitrite (15 ppm-36 ppm), cyanide (0.08 ppm-0.1 ppm), dissolved solid (200 ppm), chemical oxygen demand (index of total organic matter, abbreviated as COD: 30 ppm-46 ppm). At Raniganj the large mass of water hyacinths accumulating near the outfall of Nuniah Nalah adsorbs most of the pollutants from industries and sewage and thereby reduces the pollution load on the river at this point. At Raniganj the river receives from the Paper Mill ammonia (2 ppm-8 ppm), nitrate + nitrite (0.4 ppm - 6 ppm), phenol (0.14 ppm-0.32 ppm), COD

(130 ppm-1600 ppm), tannin and lignin (10 ppm-100 ppm); the river water assumes a reddish tinge due to tannin and lignin, which are non-degradable substances and persist over a distance of 20 km up to Durgapur barrage.

At Krishnanagar (5 km downstream of Durgapur barrage), the Tamla Nalah delivers to the river a pollution load consisting of ammonia (10 ppm-40 ppm), nitrate + nitrite (10 ppm-37 ppm), dissolved solids (200 ppm-500 ppm), suspended solids (70 ppm-240 ppm), COD (78 ppm-360 ppm), phenol (0.02 ppm-0.6 ppm) and several toxic metals including mercury (0.01 ppm-0.06 ppm). The sediment at the same site contains ammonia (50 ppm-100 ppm), COD (2.5 ppm-5.0 × 10³ ppm), arsenic (5.5 ppm-6.5 ppm), cadmium (5.5 ppm-7.5 ppm), chromium (60 ppm-100 ppm), lead (700 ppm-900 ppm), and mercury (1.0 ppm-8.8 ppm). The sediment acts as the storehouse of the pollutants and slowly leaches them to the water body enhancing its pollution level so that arsenic and mercury contamination will continue for years even after the source industries are abolished. The river in this region cannot support aquatic lives and is unfit as a source of water for domestic purposes which explains high inci-

dence of jaundice and hepatitis among the local residents.

Now let us take a look at the pollution level of the river at Durgapur barrage; ammonia (2.0 ppm-6.0 ppm), nitrate+nitrite (1.5 ppm-6.4 ppm), tannin and lignin (0.6 ppm-0.9 ppm), phenol (0.01 ppm-0.12 ppm), COD (10 ppm-200 ppm) and mercury (0.001 ppm-0.002 ppm). The river at this point remains the source of drinking water supply to Durgapur City. The water treatment plants cannot remove phenol, organic matter, tannin-lignin and mercury which will invariably contaminate the drinking water of Durgapur population. Furthermore, interaction of ammonia and phenol with chlorine gives rise to toxic chloramines and chlorophenols respectively which accompany the above pollutants in drinking water. As a matter of fact, the drinking water of Durgapur residents is not colourless, odourless and tasteless. To add to the cup of misery of the entire population in the industrial belt, the air is surcharged with flyash, fine coal dust besides other obnoxious gases which lead to numerous cases of asthma patients.

Who cares?

A final note on the destruction of the river will shock all sensible peo-



Fig.2. Boiler plant ash has given rise to a hill, swallowing up the river a good deal at Raniganj

ENVIRONMENT

ple. At Raniganj just behind one factory, boiler plant ash at the rate of about 3000 kg per day is being dumped into the river by some hundred trollies. This has given rise to a hill of ash swallowing up the river by more than 50 per cent at this point. On enquiry it appears that it neither concerns Raniganj municipality, as it is not within their jurisdiction, nor any municipality on the other side (Bankura district). This also does not seem to be a case for the State Government to be worried about. The hill of ash grows day-by-day and stands as a glaring testimony to the indifference of the public and Government alike to a crucial environmental issue.

The Damodar river, the life-line of the industrial belt and beyond, continues to get choked at Raniganj as mentioned above and quietly carries a dangerous load (much above the

tolerable level) of toxic industrial pollutants, e.g., ammonia, arsenic, chromium, mercury, etc. Arsenic and ammonia poisoning already took toll of several hundred cattle and ruined acres of agricultural fields respectively in several villages. The well-known "Minamata disease" (mercury poisoning) in Japan killed several hundred Japanese fishermen in the sixties and again in the seventies. Who knows that in W. Bengal "Minamata tragedy" is not waiting in the wings in the downstream river course from Krishnanagar onwards? But again, who cares?

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pass through the external auditory canal and cause the tympanic membrane to vibrate. A bone, called malleus, is attached to this membrane, and the vibration is transmitted through it to incus and stapes (Figs. 1 and 2). These bones magnify the vibrations. The stimuli reach the nerve endings in the organ of Corti, and are finally conveyed to the brain by the auditory nerve. The sensation of hearing is interpreted by the brain as a pleasant or unpleasant sound. Irregular sound waves produce noise; they are of very short duration and have no periodicity. On the other hand, musical sound is produced regularly, at equal intervals in equal succession.

The intensity of sound is measured in decibels (dB). The apparent loudness perceived by human ear depends on both pitch frequency and intensity of the sound. Intensities of a few community noise sources are given in Table 1. Sound consists of repeated alternate compressions and expansions of air. The pitch of sound is determined by the number of vibrations per second (frequency) and the intensity of sound (loudness) is determined by the amplitude of the vibrations. Pure tones are vibrations of single frequency, e.g., 1,000 cycles/second or 1,000 Hz. Most ordinary sounds are mixtures of tones of several frequencies. The frequencies of the greatest importance are 500, 1000 and 2000 Hertz because the sounds of human speech mostly occur in this range. The minimum intensity of a

Noise—an environmental pollutant

THE ubiquity of noise has made many people apprehensive about its possible adverse effects on public health. Noise is the sound that produces a jarring or displeasing effect. The ambient noise level of our environment has risen both with increasing population density and with increasing use of machinery as a substitute for human or animal muscle power. Airconditioners, fans, household appliances, entertainment devices, e.g., radio, television, phonographs, etc., make noise at home. Although these gadgets are signs of luxury and provide enjoyment, the disturbance they cause to natural physiological processes have not yet been assessed.

A number of industrial operations produce noise. Crushing of different materials, grinding and drilling, stamping metal into auto-fenders and punching holes into metal plates produce noise. The targets of industrial noise are mainly workers, but the noise may reach the adjoining homes too. Transportation is another source of noise. Transportation noise is generated by power units of vehicles, such as engines in jets, motors in trucks and contact of tyres on roads and

wheels on rails. Apart from the effects of vehicle noise on the surrounding community, it affects the occupant of the transportation means as well.

The question is why the sound which at one time gives soothing touch to the ear becomes noise and irritating on another occasion? In principle, sound is received by ear as pressure waves. A pressure wave is in certain respects similar to an electromagnetic wave. The sound waves

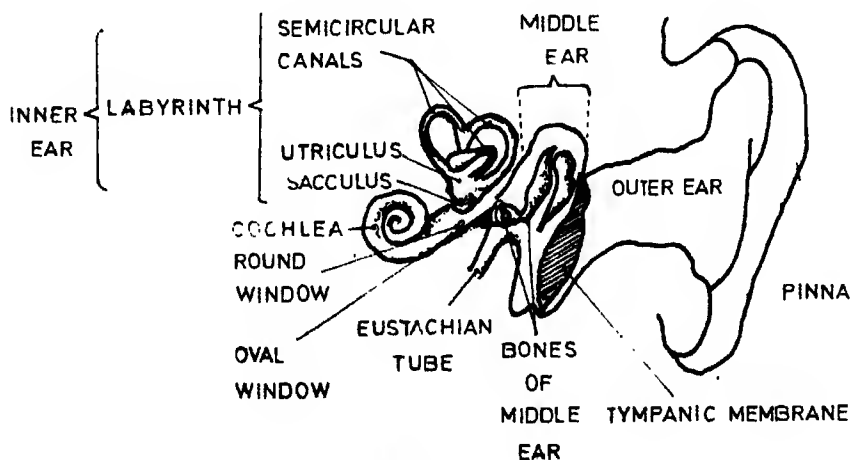


Fig. 1.

Table 1. Intensities of community noise

Range of dB	Source of noise	Minimum distance (meters)
60-70	Ordinary conversation	3
80-90	Heavy traffic (trucks, motors, cycles)	16
140-150	Jet Engines	330

sound that can be heard is called hearing threshold. When there is a shift in the hearing threshold of an individual, his hearing potential is affected and may ultimately be lost.

As early as in 1914, it was reported that prolonged exposure to high-pitched noise caused hearing loss. They were most prevalent amongst loom tenders, spinners, railway engineers and telegraphers. The reverberating noise experienced by broiler-makers and structural riveters had resulted in 'deafness' and, in the former case, has been named as "broiler-maker's deafness syndrome". It was recognised that the cause of hearing loss was due to damaged nerves in the inner ear, the damage being most pronounced for high than low tones. Hearing loss immediately after exposure to noise is greater than after a period of rest away from noise.

Hearing loss may be of two types, one is acoustic trauma, i.e., severe damage to the interior structure of the ear caused by a blast of explosion. It may take about 6-8 months to become permanent and may be corrected by surgery depending on the severity of damage. Another type of hearing loss, which is more severe than acoustic trauma, is due to a shift in the hearing threshold. Apart from affecting hearing, noise can also lead to other physiological alterations in the body such as muscle tension, constriction of blood vessels, increase in pulse rate, etc. These changes result in cardiovascular, endocrine, neurologic and other dysfunctions. On the job or in everyday life, noise interferes with recognition of sound signals. One may even fail to hear sirens or alarms. Noise interferes with sleep and disrupts normal patterns of

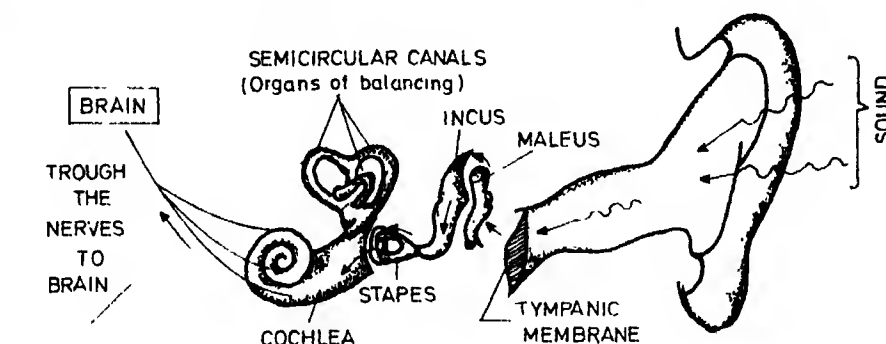


Fig. 2

animal existence.

Noise may bring about certain behavioural alterations. Continuous, moderately high levels of noise can be irritating particularly if the noise is high pitched. The irritation is a subjective feeling of annoyance or discomfort and may result in a decrease in efficiency if one is trying to concentrate, and in frustration if one is trying to hear a meaningful sound such as conversation or music. This kind of irritation is worse if the noise is intermittent than if it is steady because adaptation to ambient noise occurs fairly rapidly and the initial discomfort disappears. In fact, the absence of accustomed noise may be as physiologically disturbing as the appearance of unaccustomed noise. There is no evidence that annoying levels of ambient noise produce any long-term adverse effects and cause a diagnosable mental illness.

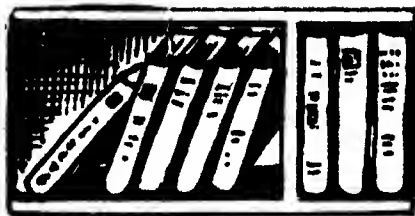
On the other hand, there is no doubt that sonic booms and noises from traffic, aircraft and other community sources are serious detractors. When there is a community consensus that these noises are public nuisance, there are grounds to seek their abatement even though health effects may not have been

clearly established, except perhaps for a gradual loss of hearing acuity. In fact, some of the hearing loss attributed to ageing may be caused by the noise level of the community environment. One study has shown a much lower hearing loss with age in a sample of primitive African males in Sudan than in American males stu-

died at Wisconsin State Fair. But a similar study of another primitive African group in Guinea failed to reveal a marked difference. Genetic and other factors may, therefore, be of major importance in the variation of hearing loss with ageing.

In a nutshell, noise is an environmental problem that requires along with chemicals, radiation, urbanization, etc., a community layout, land use, transport systems and other plans. General principles of environmental control are applied easily to noise-problem, for example, eliminate the source by substituting less noisy equipment. Jet exhausts can be modified to produce less noise. Workers in industries could possibly use ear-plugs. The noise produced by transportation, lawn mowers and construction equipment could be reduced by modifying the generators. Appropriate material in buildings could also be used to prevent entrance of noise in them. Noisy operations should be conducted in an open space, far off from any residential colony.

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BOOK REVIEWS

MINDSTEPS TO THE COSMOS by Gerald S. Hawkins, *Souvenir Press* (Available with: *Rupa & Co.*, 3831, Patauli House Road, Daryaganj, New Delhi-110002), Pp.340, Rs. 157.00 (Hardbound)

HERE is a book which gives the history of astronomy in a totally novel capsule. It divides the developments in astronomy into five major what the author calls "Mindsteps". He considers a mindstep to be "a massive change of thinking that alters the relationship of humans to the cosmos". The Mindstep 0 was taken when man began to draw pictures and symbols on the wall of his cave after watching the star-studded vault of heaven which was regularly traversed by the Sun and Moon. The Mindstep 1 was taken when man began to write myths and legends about the Gods and Goddesses, the Sun, Moon and planets that he saw in the sky, and built temples to mark their journeys. The Mindstep 2 occurred when in the ancient Greece man began to take the Sun, Moon and planets for what they are—simply objects in the sky, and began to think about their movements. At the Mindstep 3, man realised his position in the solar system and at the Mindstep 4 he began to launch rockets aimed at the heavenly objects, namely, the Moon and planets, which he had till then only deified and admired. What about the Mindstep 5 yet to follow? The author claims that probable event would be the establishment of the contact of human beings with extraterrestrial beings, probably around 2021 A.D., if the aforementioned dates of Mindsteps are any indication.

The author of the book is an eminent astronomer who has written a number of other popular books on

astronomy. Anybody reading this otherwise nicely produced and lucidly written book would certainly enjoy it but there are certain issues with which he may not agree with the author. First, the very division of astronomical developments into several mindsteps appears to be looking at the world in a narrow, astronomy-biased perspective neglecting all the contemporaneous developments. For instance, Einstein's General Theory of Relativity certainly changed our perspective towards the cosmos we live in. The author however says that it is certainly a mindstep but not of the major kind. It is something like a Mindstep 3.1 Secondly, the author has gone to great lengths to explain the various myths and legends of the past to show that they were nothing but memory devices to transmit astronomical knowledge. Even the zodiac signs, claims the author, tell a story! Perhaps, due to his own research on these lines, he got carried away. Had he given only the final interpretation and results without giving all the activities that went on in the background, the first six chapters that deal with the Mindsteps 0 and 1 would have been far more interesting to start with than what they are now.

Although this reviewer found the first six chapters unsettling and tiring due to unnecessary details, they were the ones he found original in content and intellectually more stimulating. The rest is pure history often available in other popular science books. In the first six chapters, the author has clearly shown how the myths and legends of the past regarding heroes and heroines such as Gilgamesh, Quetzalcoatl, etc., are not stories of the dimly remembered past but an ancient way of recording facts of cosmos. In fact, one is amazed to see the analogies after the legends are analysed and interpreted in terms of astronomy. The author says that the early investigators missed this point because they were not astronomers who loved mathematics and numbers. He further adds that there is a need to interpret several other legendary tales too in this manner. He has also shown in the book that ancient temples or buildings such as the Stonehenges, pyramids, etc., were also

constructed in a manner suited to the needs of astronomer-priests. His Mindstep theory fits neatly in those dim days of ancient past when two contemporary societies of England and Egypt, though diverse in all other aspects, responded exactly in the same manner to the Sun and the Moon.

The book is an excellent populariser of astronomy.

Dilip M. Saini

STEP-BY-STEP PROGRAMMING BBC MICRO, BOOK I AND BOOK II by Ian Graham, *Dorling Kindersley*, London (Available with: *B.I. Publications Pvt. Ltd.*, 54, Janpath, New Delhi 110001) Pp.64 each £5.95 each volume (Special Indian price: Rs. 50.00 each)

MICROCOMPUTERS are versatile machines that have changed lifestyles in many western countries. They have not only taken the tedium out of many household and office chores, but have also added a new dimension to home entertainment in the form of computer games and computer graphics. In schools they have revolutionised teaching. Using microcomputers students today learn faster and better than those taught by old fashioned methods.

But before a student can use a computer, he had to learn how to 'program' it. He has to learn computer language. There are several computer languages in use, but most microcomputers today use what is known as Beginners' All-purpose Symbolic Instruction Code, or BASIC in short. The two volumes under review present step-by-step instructions for programming and operating the BBC Micro using BASIC.

As a practical guide, the two volumes are unique in that they have a large format (21.5 cm x 28 cm) and are profusely illustrated with actual shots from monitor screens; (There are more than 150 of them in each volume). They show exactly how a programme or instruction would appear on the screen at the time of actual use. Even possible errors are shown as they would come up on the

screen. It is a completely new concept in the field of teach-yourself computing.

30 two-page chapters of Book I deal mostly with the preliminaries. It opens with an introduction to the BBC Micro and its operation followed by instructions for arithmetical operations like addition, subtraction, multiplication, etc., based on simple commands. Next comes the program writing part. Five chapters describe how to write simple computer programs in BASIC, how to check them and correct mistakes, and also how to converse with the computer. Eight chapters are devoted to computer graphics including three on colour graphics and simple animations. There is also a chapter on compiling a data bank and writing sub-routines. Preliminary though, they will be useful for the beginners.

Book II deals with a little more advanced computer applications including drawing curves and circles, three-dimensional graphics and writing programs for drawing bar charts, pie-charts, complex graphs and the like. Three chapters are devoted to writing computer games. Both volumes have a glossary and index at the end.

With the introduction of microcomputers for teaching in Indian schools under the computer literacy and studies in Schools (CLASS) project, there would be obvious need for well-written practical guides to computer programming. The two-volume *Step-by-step Programming BBC Micro* would ideally meet that need. Besides its simple and easy-to-follow text and superb illustrations, the heavily reduced price would be particularly attractive to Indian buyers.

Binan Basu

GRAMMATICAL MAN by Jeremy Campbell, *Penguin Books* (Available with: *Penguin Overseas Ltd.*, 706, Eros Apartments, 56, Nehru Place, New Delhi-110019), Pp. 319, £ 3.95

HOW does life appear on earth in so many forms? How were the clever, wise and inquisitive human beings evolved? How were their spe-

cial brains evolved? How did the brain evolve a grammar and a language? These are some questions that intrigue a biologist. One would be surprised to know that these questions are not related to biology alone. They are of great concern to information scientists too who are engaged in devising new ways and means to pass messages from one point to another more quickly, efficiently and economically. After all, how does a living being come into being unless the messages in its genes are encoded, transmitted and decoded to reproduce it? Today, nature is interpreted not simply in terms of matter and energy, as it was done until a few decades ago, but also in terms of information. Unless information is available on how to mould energy and matter into particular form, there is no meaning to the availability or non-availability of energy or matter.

However, information as a science came into being not due to the observations of a biologist, although from the hindsight one can call Aristotle the pioneer, it was an engineer Claude Shannon of the Bell Telephone Laboratories, USA, who gave birth to the discipline merely on the basis of his set of now famous theorems conceived in 1948. His theorems have been used to solve some problems appearing in transmission of signals in colour TVs, in designing early warning radars, and in extracting messages from signals sent by a spacecraft in space, etc. But in course of time, they have been found to have wide universal implication wherever the question of transmission of information from one point to another was concerned. They have particularly thrown light on the structure of the universe, evolution of life, language society, etc. Although the book under review gives a brief glimpse of these varied applications of information science, the main emphasis is on what makes a language so varied and creative and what role grammar plays in maintaining it to be so. To say in a few words, the book claims, on the basis of various experiments and theories, that human beings are basically grammatical in nature, the grammar acting essentially as a code for efficient and economical communica-

tions among them.

Written in a lucid and attractive style, the book first discusses in details the birth of information science, its modern pioneers such as Claude Shannon and Norbert Wiener and then switches back to the times of Sadi Carnot, James Clark Maxwell and James Bernoulli, who laid the foundations of the subject in their own ingenious ways. After discussing the elementary ideas of statistics, probability theory, randomness and entropy, it goes on to Shannon's theorems in detail. From the theorems, it leads the reader to the role of information science in nature, showing exquisitely how information theory models can be used to explain the evolution of life and the eventual emergence of man. Eventually come the intriguing questions about the origin of grammar in human brain and how the latter processes information. It sheds much interesting light on the prolific creativity of languages, how human memory works and the limitations of the human mind. At one place, it unequivocally shows that the higher purposes of human brain can never be emulated by any super computer.

The book is thought-provoking, entertaining, and refreshing.

Dilip M. Sahu

BASIC CONCEPTS OF ANALYTICAL CHEMISTRY by S. M. Khopkar, *Wiley Eastern Ltd.*, Publishers, 4835/24, Ansari Road, Daryaganj, New Delhi 110002, Pp. XVI+368, Price not mentioned.

THE extensive developments of instrumental methods for elemental and for structural analysis in the past three decades has caused a vast reduction in the teaching and study of volumetric or gravimetric methods of analysis in many colleges and universities. The existing books on analytical chemistry have either stressed too much details of classical gravimetric and volumetric analysis or have overemphasised the role of instrumental analysis. This volume is a blend of classical and instrumental methods of chemical analysis and may help redress the balance. It is designed to be used as a text book for postgraduate courses for both main stream and ancillary courses.

BOOK REVIEWS

The first few chapters give brief but reasonably thorough accounts of newer separation methods including solvent extraction as well as novel chromatographic methods. This includes gas chromatography, high performance liquid chromatography and ion exchange methods. The approach is quantitative and numerical supported by numerous fully worked out examples and tabular materials. Instrumental methods are neatly introduced via the common ground of working curves and method of standard additions. The instrumental methods included were chosen on the basis of being those most likely to be met with and used by postgraduates. They include spectroscopic methods such as UV, visible IR, AAS, molecular luminescence methods, the techniques used for elucidation of structure such as NMR, ESR, mass spectrometry, optical rotatory dispersion (ORD) and circular dichromism. The important electroanalytical methods like potentiometry, polarography, conductometry and coulometry along with ion selective electrodes are adequately covered. Other modern physico-chemical techniques of analysis included are thermoanalytical, radiochemical methods and conclude with a discussion of laboratory automation.

The source of material in his book is well referenced. Based upon the author's teaching course at Indian Institute of Technology, Bombay, the text reaches its target effectively. The author has written a book which in many ways is unique and can be warmly recommended as a worthwhile addition to the literature of analytical chemistry.

S.D. Panwar

THEORY AND PRACTICE OF ANIMAL TAXONOMY by V.C. Kapur, 1983, Oxford & IBH Publishing Co., 66, Janpath New Delhi 110 001, Pp. 220, Rs. 19.50

A glance over the references listed in this work would reveal that there is no dearth of reviews on the principles of animal taxonomy. Then, why this, another book? The author has justified the undertaking on the ground

that there exists no Indian book on the subject. While it is true that foreign publications are too highly priced, and to this end an indigenous product such as this should be welcome, it is disappointing that the present work, by no means, comes anywhere near a comprehensive treatise such as Ernst Mayr's *Principles of Systematic Zoology*, published in 1969. It has, on the other hand a 'made easy' look, typical of the stuff dished up in book stores as examination guide material. Nevertheless the book under review may succeed in opening the right door for the uninitiated and serve to stimulate the taxonomic thought at the undergraduate level itself. This is peremptory in view of the hard fact that systematic zoology in our curricula takes a back seat despite the enormity of faunal wealth of the Indian subcontinent and the rich potential it holds for evolutionary biology studies.

A paperback in demi octavo size, the book has an attractive exterior. However, for its continued acceptability in future, the book will have to be rewritten citing as many local examples as possible (to sustain the claim of its Indianness) and enlarging on modern topics, such as DNA hybridization. Also, half-tones will have to be done on art paper, and English expression checked by an expert.

The book is worth a trial in any case.

B.S. Jangl

INTRODUCTION TO NUCLEAR SCIENCE by M. N. Sastri, Affiliated East-West Press Private Ltd., 104 Nir-mal Tower, 26, Barakhamba Road, New Delhi, Pp. 169, Rs. 17.00

THE phenomena of radioactivity discovered some ninety years ago undoubtedly marked the beginning of a new era in physics. It was this discovery which prompted scientists to peep into the world of atomic nucleus uncovering its structure and exploring its various properties. In fact, many suggestive discoveries about the atom such as isotopic constitution, artificial disintegration, induced

radioactivity, etc., were a result of this remarkable phenomena. Nuclear science and techniques have now profound impact on all branches of science. Therefore, it becomes necessary for students and workers in all fields of science to get themselves acquainted with the basic information about this discipline. The present book has been written primarily to meet this requirement.

Running through ten chapters, the book is an attempt to familiarise the readers with the basic concepts and principles of nuclear science. The book opens with a historical introduction to the phenomena of radioactivity. Nuclear structure is discussed in chapter 2 while chapter 3 is concerned with the laws of radioactive decay. Nuclear reactions are treated in chapter 4 while the various radioactive decay processes are described in chapter 5. Interaction of radiation with matter forms the subject matter of chapter 6. Detection and measurement of nuclear radiations are given coverage in chapter 7. Theory of nuclear fission and description of nuclear reactors are included in chapter 8 while chapter 9 discusses the chemical and biological hazards of radiations. The concluding chapter 10 is devoted to the applications of radionuclides including their uses in medicine, biology and agriculture.

The book has been written in a very easy-to-follow style. The presentation is lucid. The mathematics used is simple. Some worked examples are also included in the various chapters which besides increasing the utility of the book also help in the better understanding of the topics. However, unfortunately, in chapter 4 some mistakes have crept in development of equations (4.1a) to (4.2) which can create some confusion. The reviewer hopes that they will be removed in the new edition of the book. Also, at several places the word "radicle" has been erroneously used in the book which looks very awkward. However, these are very minor points which can be easily taken care of. The readers will certainly find the book useful and interesting and will benefit from it. It can also serve as a

reference book for general as well as research purposes.

P.K. Mukherjee

CHEMISTRY FOR CLASS XI by N.R. Bannerjee, R.K. Trikha and N.K. Nayar, *Tata McGraw-Hill*, 12/4, Asaf Ali Road, New Delhi-110002, 1983, Pp. 324, Rs. 24.00

THIS book which is based on the class XI syllabus of the Central Board of Secondary Education, Delhi, is primarily intended to serve as the bridge course for classes IX, X and XII of the 10+2 system. Both standards and syllabi have changed a lot and much needs to be done to make learning a pleasure and not the drudgery it has become. Keeping in view the level of understanding and capacity developed by the students to grasp the subject at earlier course, authors have succeeded in presenting the concepts of chemistry in systematic sequences. Each chapter is independent by itself and cross-references have avoided First chapter on structure and scope of chemistry sets the scene for nineteen chapters strictly adhering to the syllabus prescribed by CBSE. This synchronised treatment of subjects

projects chemistry as a rational subject and not merely as an assortment of unconnected facts.

Throughout the text, examples and illustrations have been provided to explain the bonds between various atoms or groups according to modern approach. Concept of orbital overlap in bond formation, hybridisation, shapes of molecules and an elementary treatment of metallic and hydrogen bonds have been adequately dealt with according to electronic configurations. A large number of objective-type questions which are becoming popular have been appended after each chapter so as to give the student an opportunity to test his knowledge. Based upon the authors' long experience of teaching, this text is sure to be useful to students. One of the authors Dr. Bannerjee is the co-author of *Chemistry for Class XII* (Tata McGraw-Hill) which is recommended by the CBSE. Like his first book the book under review may also be recommended by CBSE.

S.D. Panwar

Books Received

1. **PETROLOGY OF DECCAN TRAPS AND BAGH BEDS OF DUGHANASWADI, GUJARAT** by L. G. Gwalani, *Somaiya Publications Pvt. Ltd.*, 172 Mumbai Marathi Granthasangrahalaya Marg, Dadar, Bombay-400014, Pp. 107, Rs. 65
2. **COMPUTERS AND THEIR USE: AN INTRODUCTION—Teach Yourself Books** (Available with: *B.I. Publications*, Promotion Department, 61-63 Lakshmi Building, 4th Floor, Sir Phirozshah Mehta Road, Bombay-400001), Pp. 168, £ 2.50
3. **WORD PROCESSING WITH THE SINCLAIR QL** by Mike O'Reilly (Available with: *B.I. Publications* Promotion Department, 61-63 Lakshmi Building, 4th Floor, Sir Phirozshah Mehta Road, Bombay-400001), Pp. 170, £ 6.95
4. **INTRODUCING THE SINCLAIR QL** by Garry Marshall (Available with: *B.I. Publications*, Promotion Department 61-63 Lakshmi Building, 4th Floor, Sir Phirozshah Mehta Road, Bombay-400001), Pp. 175, £ 6.95

Corrigenda

1. Ref. S.R., October 1984, The fascinating geckos, P. 547, legend for Fig. 2, Read *Eublepharis macularius* For *Eublepharis macularious*
2. Ref. S.R., September 1984, The mononuclear power: an answer to energy crisis; P. 451, second column, 13th line from bottom Read plane For place, P. 452 second column 9th line from top Read U S 2×10^8 For 2×10^6 , P. 490, Further reading No. 10, Read (1934) For (1945)
3. Ref. S.R., Sept. 1984, On positioning of satellites, Pp. 438-439, Read Figure legends as: Fig. 1 Attitude control, Fig. 2 Satellite orbits, Fig. 3. Periods and velocities in orbit. Consequently in text Read Fig. 2. For Fig. 1., Fig. 3 For Fig. 2. and Fig. 1 For Fig. 3.

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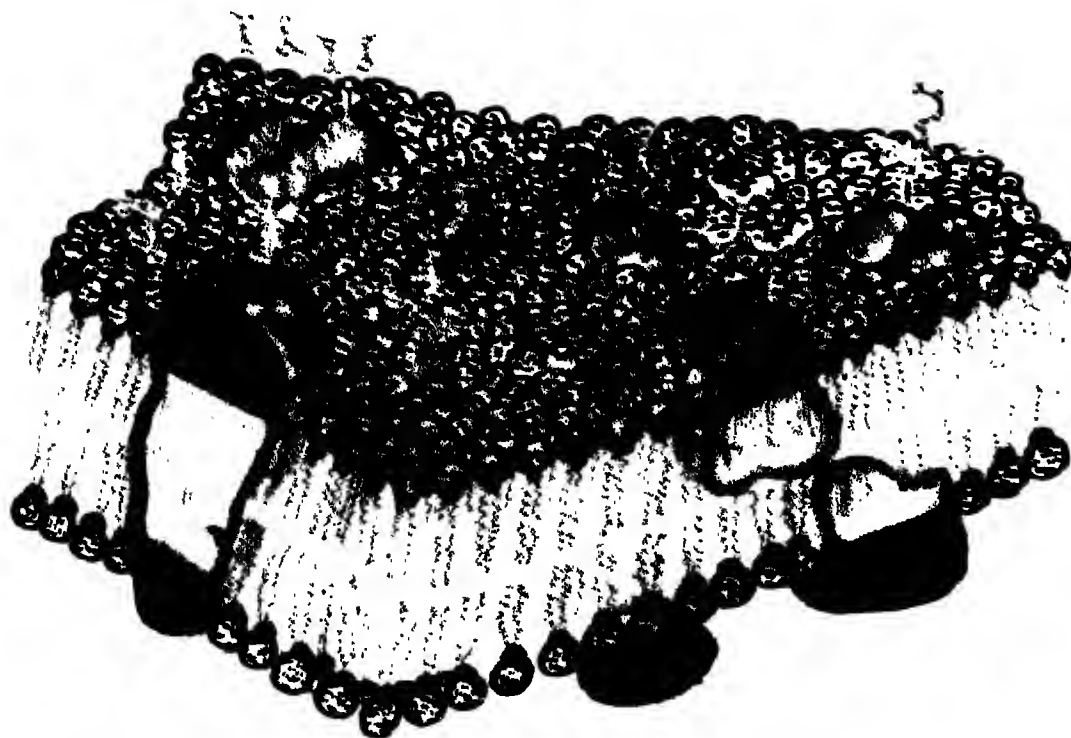
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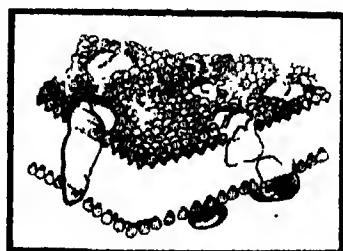
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JUNE 1985
VOL. 22 NO. 2

SCIENCE REPORTER

JUNE 1985
PAPER ONE



PLASMA MEMBRANE



COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH
(Publications and Information Directorate, New Delhi)

Science Reporter is published monthly. Publications and Information Directorate (CSIR) assumes no responsibility for statements and opinions advanced by contributors and the editorial staff.

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Annual Subscription

Indiad Rs. 18.00
Foreign (By surface mail) \$ 5.00

Phones: Editorial, Production & Sales—56-6301, 56-6308, 56-6385

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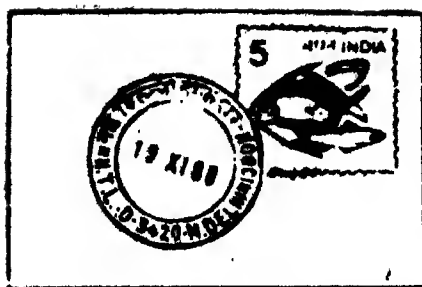
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LETTERS

Meat-rinsed water sweetens fruits of *Punica granatum* L. (Anar)

Sir, *P. granatum* is the monotypic genera belonging to the family Punicaceae. A survey of literature reveals that use of meat-rinsed water to increase sweetness of fruits of this plant has been described for the first time. In addition, the various parts of the plant are medicinally important. The root bark and stem bark are astringent and anthelmintic, whereas rind of the fruit in combination with aromatics like cloves, etc., is useful in dysentery. Dried seeds are used in stomachache. Bark contains various alkaloids like pelletierine, pseudopelletierine, iso pelletierine and methyl pelletierine (Chopra et al., 1956).

People in various parts of Haryana have been getting fruits of *P. granatum* significantly sweeter than the normal ones with application of meat-rinsed water in their kitchen gardens. The approximate dose per plant is 1-2 litres; one at the interval of one week. Usually these people put meat-rinsed water at the base of the plant two months before the flowering season. The meat-rinsed water given plants yield several times sweeter and dark-red edible part of the seeds than those which have not been given this water. The former are more delicious than the latter.

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Thyroid hormones

Sir, I enjoyed reading *The enigmatic thyroid hormones* by V.K. Pathak and A.K. Patl (S.R., October 1984) but I would like to point out that the list given by the authors enumerating the symptoms produced by hypothyroidism is not complete.

Clinical features of primary hypothyroidism also include vague, generalised pains, deafness, impairment of memory, tingling sensation in the fingers and delayed relaxation of tendon jerks. Anaemia and pain in muscles or joints are the less commonly found features which in late stage culminate in 'myxoedema madness' (with psychoses and hallucinations) and coma.

Secondly, I would like to add that the curious thing which escaped the authors' attention is the occurrence of hypothyroidism more frequently in women than in men, the ratio being 8 to 1. Hypothyroidism, too, mainly affects middle-aged females, although it can occur in either sex at any age. These things, *Inter alia*, make thyroid and its hormones a real enigma.

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Revolving numbers

Sir, *The Revolving numbers and revolving pairs* (S.R., Sept. 1984) claimed to have been discovered by A.K. Sahu with the help of a calculator by trial and error has actually been pirated from the book *Vedic Mathematics* by Jagadguru Sankaracharya of Puri published by Motilal Banerjadas, 41-UA, Bungalow Road, Delhi-7 in 1965.

The first revolving number 142857 is nothing but the recurring decimal fraction of $1/7$. Similarly, the second and third revolving numbers of 16 and 18 digits respectively, viz., 1176470588235294 and 1052631578944736842 are the recurring decimal fractions of $2/17$ and $2/19$.

As regards the revolving pair, the fraction of $1/13 = 0.076923153846$ has been divided into two pairs as X/076923 Y/153846 such that one is double of the other. The other revolving pairs have also been copied from the said book and reproduced in the article.

J.P. Malik
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The fusion remedy

Sir, Many scientists visualise it as the ultimate answer to the energy crisis which the world is undergoing nowadays. It actually promises limitless energy and perhaps more, but poses the greatest and most difficult technological challenge ever faced by mankind. What is it that creates so much 'energy' in us, which marks a new epoch in nuclear physics? It is indeed nuclear fusion.

Fusion is the process that makes the sun and stars burn, and it provides the hydrogen bomb with such powers that it can disrupt all human activity for ages together. Unlike the familiar fission reaction, which splits the heavy atoms, a fusion reaction joins the nuclei of two light atoms, in this case deuterium (heavy hydrogen) and tritium (atomic weight-3) forms of hydrogen. In both cases loss of mass results and tremendous energy is released.

To achieve fusion, scientists must recreate the extreme conditions that exist inside the sun, where heat reduces matter to an ionised gas called plasma.

Fusion offers immense advantages over our modern fission reactors. But fusion technology is so complex that some scientists feel that it will never be inexpensive to use. In any case it

can be said confidently that commercial fusion will not come before the year 2000 A.D.

**K. Ramchandran
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Rabies

Sir, Ref: the article Rabies and dogs by P.A. Hamza (S.R., November 1984), I would like to add the following:

(I) An inactivated rabies vaccine

(human diploid cells) is the latest of its kind. It requires a dosage of only 6 injections of 1 ml each as post-bite vaccination. It is almost painless and free from side-effects. It has been prepared by INSTITUTE—MERTEUX Lyon, France, and is now freely available in India.

(ii) The principle of preventive vaccination should basically be followed by workers who are exposed to repeated risks of infection such as (a) veterinary surgeons (including students of veterinary colleges), (b)

technical personnel assisting veterinary surgeons, (c) laboratory personnel who handle material contaminated by the rabies virus, (d) personnel of slaughter houses and meat preparation units, (e) animal dealers, and (f) game-keepers, forest rangers in areas of enzootic diseases.

**Maneesh Taneja
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Attention Readers

Due to some unavoidable reasons, we have not been able to publish issues of *Science Reporter* for the months of Feb. 1985 through May 1985. Subscriptions already paid to us will be extended to cover the four skipped issues. We request our readers to bear with us.

—Editor

HOW PLASMA MEMBRANE FUNCTIONS

SAROJ LARROYA

G.K. KHULLER

The membrane that surrounds a biological cell plays a vital metabolic role by regulating the passage of molecules across it

PLASMA membrane, surrounding a biological cell, is not merely a boundary between cellular contents and the environment but is an organelle capable of regulating diversified functions of the cell. Animal cells differ from plant, fungal and bacterial cells in being devoid of cell-wall. However, presence of plasma membrane is universal. Bacterial plasma membrane is more complex because it also houses respiratory-chain (or electron transport chain), which is present in mitochondria of eukaryotic cells.

To understand functional activities of a biomembrane, knowledge of its structural organization is very important. The first model explaining mem-

brane organization and functions was postulated by J.F. Danielli and H. Davson in 1935. However, later many other models were put forward. The most acceptable model today is the Fluid-Mosaic model of S.J. Singer and G.L. Nicolson (1972). According to this model, the matrix of a membrane is composed of lipid molecules arranged in a bilayer (i.e., two layers) while proteins are embedded in the bilayer either completely or partially (Fig.1.a). Membrane proteins belong to two categories: loosely bound ones (or peripheral proteins) and tightly bound to the lipid bilayer (or integral proteins). Some of the integral proteins may extend across the thickness of the membrane. Never-

theless, translational diffusion of integral proteins within plane of the membrane can occur without alterations in their molecular orientation and degree of intercalation into the membranes.

The major lipid constituents of cytoplasmic membrane are phospholipids, popularly known as polar lipids. A phospholipid molecule has glycerol as its backbone to which two fatty acids are esterified at carbon 1 and 2, while phosphoric acid is esterified to carbon 3 of glycerol. Further, an alcohol group is esterified to phosphoric acid to constitute polar head group of the phospholipid (Fig.1.b and c). Examples of various alcohol groups are choline, ethanolamine, inositol, serine and glycerol. A phospholipid is named after the type of alcohol group present, e.g. choline containing phospholipid is known as phosphatidylcholine.

Major portion of phospholipids of a cell is present in the membrane(s). These polar lipids are never stored for energy purposes. Non-polar lipids, being exclusively fuel lipids, are rarely present in membranes. Triglycerides or fats, being highly hydrophobic (disliking water), are finely dispersed and emulsified throughout the cell fluid. In animals, fats can be stored in specialized tissues to form fat-cells or



Fig.1. (a) Fluid-mosaic model for membrane structure (a) sugar residues of glycolipids, (b) an integral protein, (c) hydrophobic zone of the lipid bilayer and the proteins embedded, and (d) hydrophilic zone of the membrane

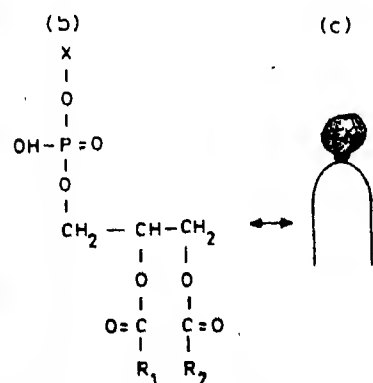


Fig.1. (b) Chemical structure of a phospholipid molecule (c) Diagrammatic representation of a phospholipid molecule

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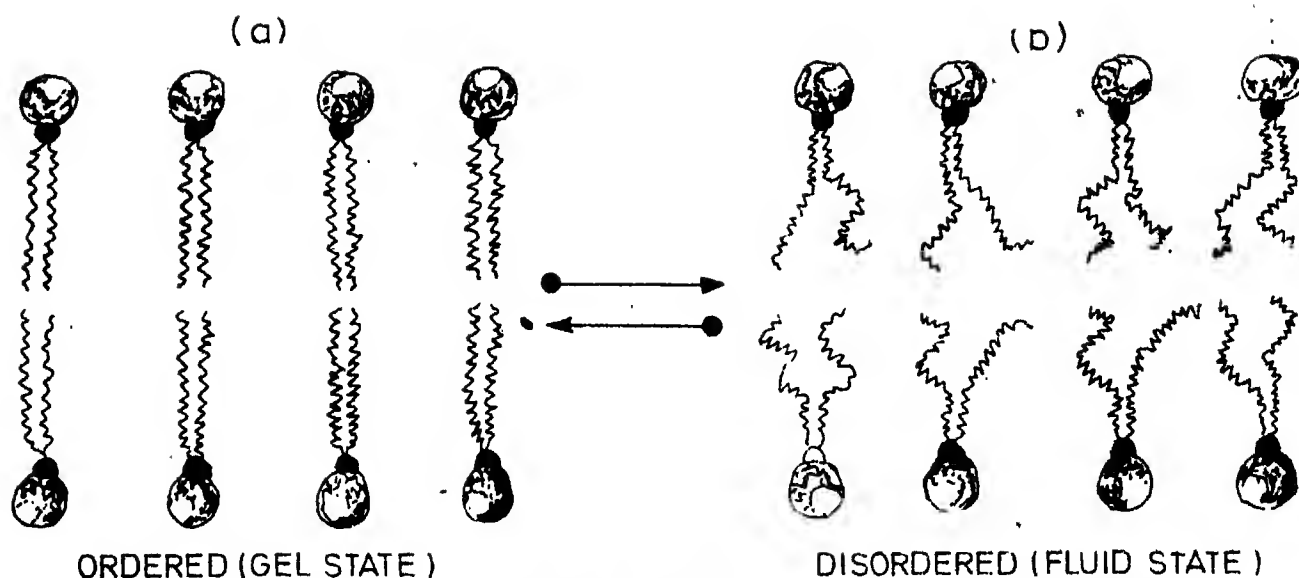


Fig.2. Mobilities of fatty acid chains in the ordered (gel state) and disordered state (fluid state) of lipid bilayer

adipocytes; also meant to provide insulation for maintenance of body temperature.

Exclusive localization of phospholipids in membranes can be attributed to their amphipathic nature. The fatty acyl chains form the hydrophobic group while the polar head group imparts hydrophilic (liking for water) character to the molecule. Therefore, polar head groups in the lipid bilayer face aqueous compartments while fatty acyl chains face each other to form the hydrophobic core of the matrix (Fig. 1 a). Maximum resistance to the entry of hydrophilic and polar solutes is offered by this portion of the bilayer. Integral proteins also show amphipathic nature; the polypeptide chain is so folded in the membrane that only polar groups of the constituent amino acids face the aqueous compartment(s) whereas nonpolar groups are shielded away. Most of the integral proteins have either enzymic functions or solute transportation functions.

Membranes possess a variety of phospholipids due to all possible combinations between the constituent fatty acids and polar head groups. Under normal conditions of temperature, membrane components exhibit varying degrees of mobility (or fluidity). Generally, an unsaturated fatty acid is present at carbon 2 while satu-

rated fatty acid is at carbon 1 of the glycerol residue in a phospholipid molecule. However, presence of phospholipids having cis-unsaturated fatty acids at both the positions (carbon 1 and 2) of the glycerol backbone results in a more fluid membrane. Presence of a double bond (cis form) produces a bend or a kink of about 30° in configuration of the fatty acids (Fig. 3) and also lowers melting point of the unsaturated fatty acids, as compared to its analogous saturated fatty acid.

Lowering of melting point of membrane phospholipids by increased abundance of monounsaturated or

diunsaturated (cis form) fatty acids results in a more fluid membrane, even at normal temperatures. An analogy can be cited to explain why the membrane lipids having cis-unsaturated fatty acids are more fluid. Natural oils (e.g., vegetable oils) are liquid at room temperature because of predominance of unsaturated fatty acids, however, on hydrogenation (double bonds are abolished) these oils turn into a solid mass at room temperature (e.g., vanaspathi ghee). When the ambient temperature falls a condition may arise when mobility of fatty acyl chains of phospholipids gets restricted and consequently

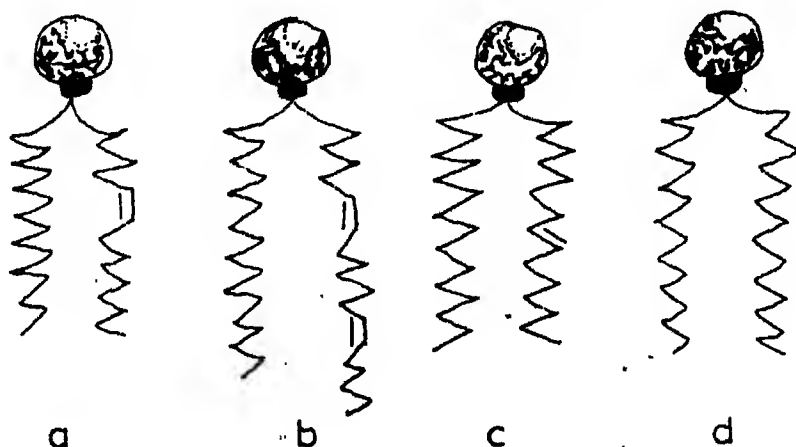


Fig.3. Diagrammatic representation of (a) Cis-monounsaturated, (b) Cis-diunsaturated, (c) Trans-monounsaturated and (d) Saturated fatty acid

membrane permeability decreases; such an ordered state of membrane lipids is known as gel state (Fig. 2 a). On the other hand, increase in temperature of the surroundings of a cell results in a more fluid (or disordered) state as a consequence of increased mobility of fatty acyl chains. Since complete migration of phospholipid molecules does not occur following changes in the ambient temperature, movements of phospholipid acyl chains can be compared with ballet dancing (Fig. 2 b).

Changes in membrane fluidity is known to affect enzymic and solute transport functions of various integral proteins. Once membrane functions are altered, metabolism of the cell may also get modified. Hence, plasma membrane not only stands between a living cell and its environment but also serves as a regulatory site for important metabolic reactions.

Besides phospholipids, glycolipids (lipids having sugar residues) and steroids (in particular, cholesterol) are invaluable structural entities of plasma membrane. Glycolipids generally act as surface-receptors for hormones, cell-cell recognition and adhesion phenomenon. Cholesterol, present in mammalian membranes, is as important as fatty acids for maintenance of membrane fluidity. However, cholesterol affects fluidity in a manner opposite to that induced by changes in temperature, i.e., cholesterol acts as a buffer during severe alterations in mobility of phospholipid acyl chains.

After having an idea about structural organization of a biomembrane, it would be fascinating to examine how membranes function in a living cell. Complexity in structure of membranes is responsible for selective permeability properties of plasma membrane; permitting some molecules to enter and others to extrude out of the cell. In addition, it controls osmotic and electrolyte balance across its exterior and interior sides. Molecules which enter a cell are not allowed to simply come out, which is another important function of biomembranes. Further, cytoplasmic membranes are well equipped to guide cellular accumulation of some substances in concentrations much higher than those present outside the cell

of the cell (Fig. 5). It can be of three types:

(i) **Primary active transport system.** Here the energy used comes from the Various types of systems are encountered in prokaryotic as well as eukaryotic cells for transportation of solutes and ions across membranes.

In passive transport, a solute is transported down the concentration gradient, till concentration of the species becomes equal on both the sides of the membrane. However, the operation does not require cell energy. Passive transport may be of two types:

(i) **Simple diffusion.** Here the solute molecules simply diffuse across the lipid bilayer. This type of transport system is meant for hydrophobic (or lipophilic) substances and small polar molecules. Hydrophobic substances, e.g., fatty acids and other lipid species, are believed to simply dissolve in the hydrophobic core of lipid bilayer, whereas small polar molecules (like water) may pass through the kinks or spaces produced momentarily during mobility of the fatty acyl chains.

(ii) **Facilitated diffusion or carrier-mediated transport.** In this type of diffusion, solute molecules take the help of a protein called carrier to cross the barrier imposed by lipid bilayer. The solutes falling in this category are generally hydrophilic, large polar molecules or electrolytes. It is believed that the carrier (C_1) on the exterior membrane surface combines with the solute (S) to form the carrier-solute complex (CS_1), which can exist in two forms CS_1 and CS_2 at two sides of the membrane (Fig. 4). To release the solute on second side (towards interior) a conformational change occurs releasing the solute inside, while the carrier (as C_2 form) is set free. However, to transport another molecule on the exterior face, the carrier gets converted to its original conformation (C_1) and repeats the sequence. Here again the transport process continues till equilibrium is reached for the solute concentration and/or its charge across the membrane.

In active transport, besides requiring a carrier, solute is accumulated against concentration or electrochemical gradient by utilizing energy of the cell (Fig. 5). It can be of three types;

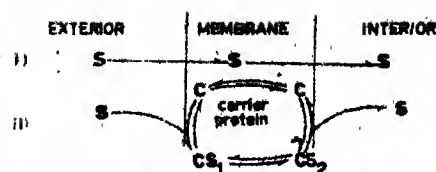


Fig. 4. Passive transport (i) Simple diffusion, (ii) Carrier-mediated transport

(i) **Primary active transport system.** Here the energy used comes from the hydrolysis of ATP (a high energy compound) to ADP + P_i . After transportation of the solute, energy is required to energize the carrier for repeating the cycle (i.e., to carry another molecule towards interior). This type of transport is rare in prokaryotes but it is quite common in eukaryotes.

(ii) **Secondary active transport system.** Here, two solutes share a common carrier, out of which one solute (actual substrate) is to be transported or driven against the concentration gradient, while the other one is the 'driving solute', usually a cation like Na^+ , H^+ , K^+ or Ca^{2+} . The cation may move in the same direction (when it is called co-transport) or in the opposite direction of the substrate (when it is known as counter-transport). Cell energy is used here to push the cation (or the driving solute) back to its original compartment for maintenance of electrochemical (commutative gradient of charge and mass) gradient. This is unlike primary active transport, where energy of ATP hydrolysis is directly applied to the carrier-protein for its energization.

(iii) **Group translocation.** Usually a phosphate group is attached covalently to the solute (thus forming a

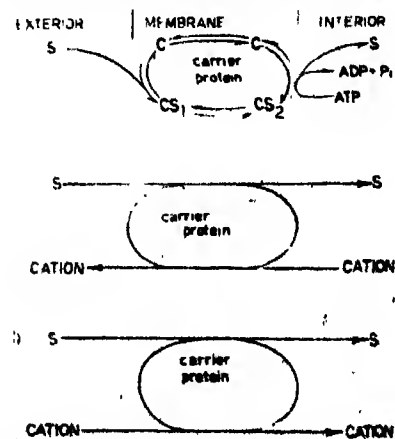


Fig. 5. Active transport (Top) Primary Active transport, (Middle) Counter-transport and (Bottom) Co-transport system

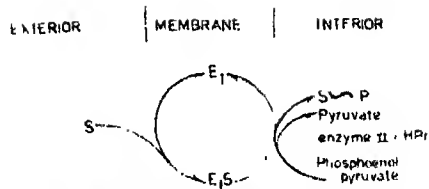


Fig. 6. Schematic representation of Group translocation system.

group) while it undergoes carrier-mediated transport from exterior to interior of the cell (Fig. 6). As chemical species of the solute changes during transportation, this type of system actually does not fulfill the conditions laid down for an active transport phenomenon. However, many a times it is categorized under active transport system because energy is utilized to accumulate the solute, though modified, in concentrations much higher than present in the surroundings. This type of transport system is indispensable for sugar transport in bacteria, especially for anaerobic ones, since the phosphorylated sugar molecule can be directly utilized in carbohydrate metabolism as such. In animals, group translocation system for amino acids only has been reported in various tissues.

Recent knowledge about membrane functions has been derived from studies involving the use of either membrane vesicles or artificial membranes. Membrane vesicles are spherical bodies formed when a cell is completely disrupted, its membrane fractions isolated (by differential centrifugation) and purified by density gradient centrifugation, and are resuspended in a suitable buffer with slight shaking. Membrane vesicles have the advantage over intact cells that despite retaining biological functions of all membrane components (i.e., of lipids as well as proteins) transportation of solute is independent of the cellular metabolic pool. Hence, a true rate and concentration of the solute transported can be determined by using membrane vesicles.

Artificial membranes (or liposomes) are prepared by dispersing phospholipids using ultrasonics in aqueous solutions. These lipids are either extracted from natural membranes or are prepared synthetically. The spherical structures produced, called liposomes, possess one or

more concentric bilayers of phospholipids (Fig. 7). Each bilayer encloses an aqueous compartment inside. Surprisingly, many properties of natural membranes are mere reflections of their phospholipid composition. Therefore, liposomes serve as models for natural membranes. Since liposomes are devoid of metabolic pool of the cell as well as of proteins, the role of chain length of fatty acids, their degree of unsaturation, and size and charge of polar head group on transport functions can be studied in a true sense. Not only the fatty acyl chains of phospholipids but also their polar-head group composition influence membrane properties. N. Muranushi and co-workers (1981) have suggested that the incorporation of non-polar or neutral lipids into liposomal membranes does not influence the membrane permeability appreciably. However, presence of phospholipids having low melting carbon chains (i.e., having polar head as well as unsaturated acyl chains) tremendously increase the membrane permeability. M. Shinitzky and P. Henkart (1980) from their own observations as well as from other studies have concluded that phosphatidylcholine, phosphatidylserine and phosphatidylglycerol act as membrane-fluidizers while phosphatidylethanolamine, phosphatidylinositol and cholesterol generally behave as

rigidifiers. Hence, the ratio of fluidizer to rigidifier lipids is extremely crucial in determining membrane functions. Once again we see that functioning of a biomembrane is inherent to its structural organization.

Liposomes are gaining popularity due to their numerous applications in biology as well as in medicine. In biological sciences, liposomes are used to study phenomena like endocytosis, induction of cell-cell fusion and alteration of membrane lipid composition. The biological uses of liposomes depend upon their property to fuse amongst themselves or with other living cells in presence of calcium ions. Another contribution of liposomes to biology is in understanding the specific role of a specific membrane protein. The aim is achieved by carefully inserting an isolated and purified natural membrane protein into liposomes of known lipid composition. The resulting structure, called proteoliposome, has been exploited thoroughly to assign biological functions to many membrane proteins. As membrane vesicles possess varied types of proteins simultaneously, proteoliposomes serve as better models to test functions of isolated natural proteins.

In medicine, liposomes have been used as pharmacological capsules to

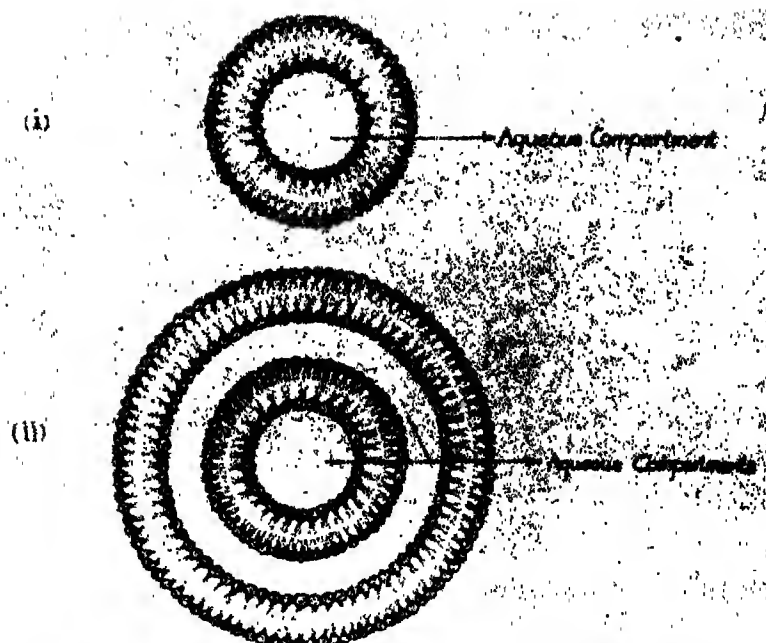


Fig. 7. Diagrammatic structure of liposomes (I) Unilamellar (II) Bilamellar

(Continued on page 112)

HIGH PRESSURE TECHNIQUES FOR SOLID STATE MATERIALS

Materials show unusual behaviour under high pressure from which a wealth of data can be obtained about their structure, optical and electronic properties

ASHOK K.SAXENA

SOLID state materials can be broadly classified into three categories, namely: (i) metals, (ii) insulators, and (iii) semiconductors. The suitability of these materials for various electronic applications is determined largely by the details of their band structure. For example, in metals, the energy band gap is zero while in insulators it is of the order of a few eV. On the contrary, semiconductors have energy gaps which lie between those of metals and insulators. The band structure configuration, including the energy band gap is, in turn, determined by the lattice constant and interatomic spacing of the structure in which the material crystallizes. To quote, elemental semiconductors Si and Ge have diamond type crystal structures while 3-5 group semiconductor compounds (GaAs, GaSb, InP, etc.) have zinc blende structure. So, the lattice constant is the most intrinsic property of all materials. It will not be unwise to foresee considerable changes in their band structures and, also, the electronic properties as the lattice constant is somehow altered from its equilibrium value at atmospheric pressure.

Among the thermodynamic variables, pressure is often regarded as a poor parameter of a material. Today, it is known beyond doubt that the effects that can be observed in solid state materials under both hydrostatic and unidirectional pressures can be magical and highly informative as the lattice constant is changed. A

wide range of structural, optical and electronic properties is exhibited as the materials are subjected to high pressures. Due to shortage of space, this article will deal with the hydrostatic pressure techniques only and the resulting changes in the characteristics of the materials. In addition to the reduction of the lattice constant, the atoms (or molecules) of the material under pressure may rearrange themselves in an interesting way. Some solids do not have the highest packing density of atoms at atmospheric pressure and this density has been found to change with pressure. So, many solids have been observed to undergo such changes, such as conversion of diamond into graphite, InAs semiconductor with a zinc blende structure into an NaCl type structure, and so on. Under pressure, insulators have been found to behave like semiconductors and semiconductors like metals.

Some of the areas where the application of pressure has been noticed are: (i) observation of new phase transitions in solids; (ii) NMR phenomenon in alloys; (iii) band structure determination and high field effects (GUNN Effect in 3-5 group single crystal semiconductor compounds; (iv) observation of tricritical points in ferroelectric materials such as BaTiO_3 ; (v) metal semiconductor transitions and band structure determination of chalcopyrite structures for optical devices; (vi) investigation of semiconducting materials for high sensitivity pressure sensors; and

(vii) study of two dimensional electron gas in semiconductor heterostructures.

The observation of certain phenomena in solid state materials may need pressures approaching as high as a few hundreds of a Kilobar (1 Kilobar = 10^9 dynes/cm² $\approx 10^3$ atmosphere). Investigations on solid state materials need samples of a very small size (~ 1 mm² with a thickness of a few hundred microns) so that the bulk properties could be studied.

Experimental techniques

High pressure (hydrostatic) generation techniques can be divided into the following groups depending upon the range of pressures required for the experiment.

Low pressure technique. Fig. 1 is a schematic line diagram of a typical piston-cylinder assembly within a four column die set. This is constructed by having an outer ring and an inner cylinder made up of a die steel. The inner cylinder is pressed into the outer ring with a small angle ($\sim 1^\circ$) of taper. The piston containing the sample under investigation is pressed from the top into the liquid contained in the cylinder. An enlarged photograph of the inverted thrust piston made up of high speed tool steel is shown in Fig. 2. The sample holder consists of a metal (insulated) frame which can be easily inserted between the poles of a magnet. The provision of the magnet is made for specific types of experiments like Hall effect and magneto-resistance measure-

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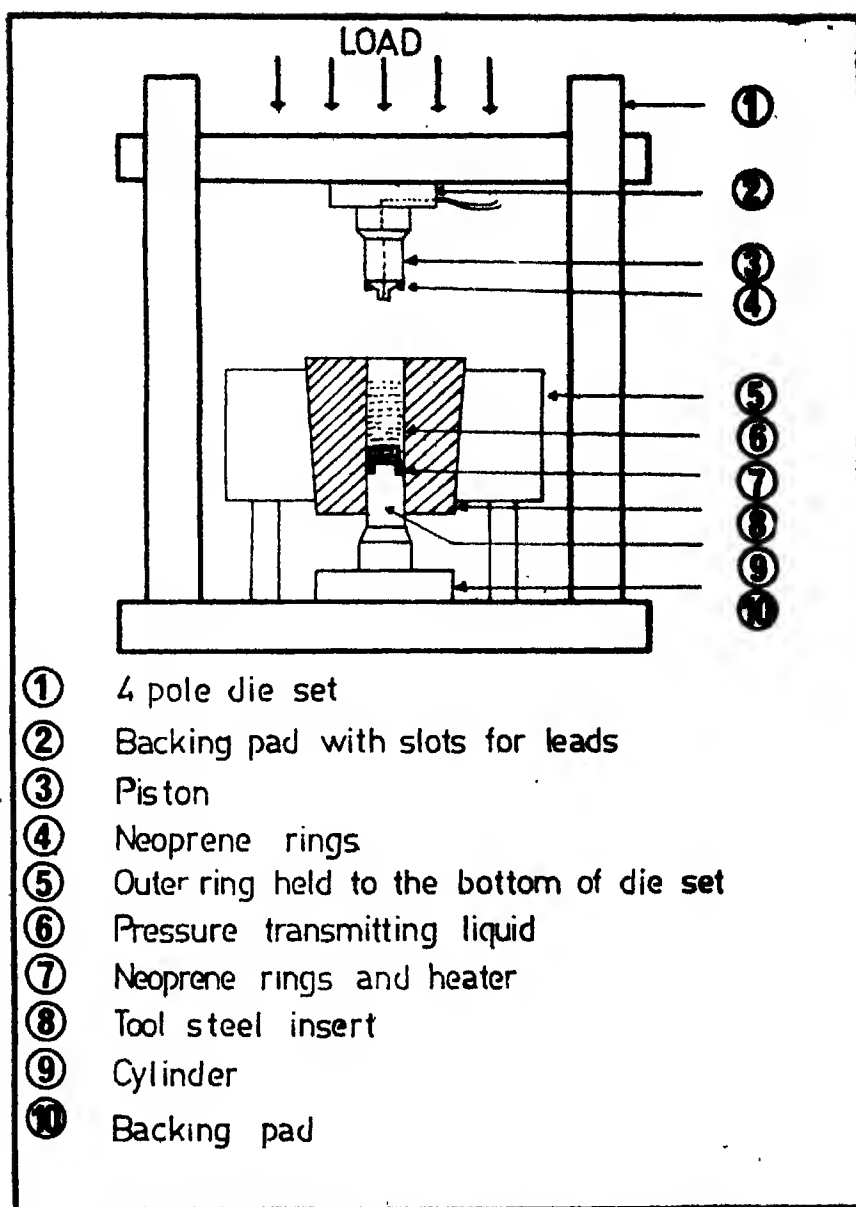


Fig. 1. Schematic line diagram of cylinder-piston assembly

ments. The magnetic field is provided by passing a constant current through the coil wound round a toroid of a high quality mild steel and placed at the top of the piston. To measure the pressure inside the cell, a manganin gauge is wound on a PTFE former and held at the top of the magnet by a screw threaded into the top of the piston for taking the leads (from the sample, magnet, thermocouple and the gauge) out of the piston-cylinder assembly. A technique of hardened silver steel terminals into ceramic sleeves is used for taking the leads out of the pressure chamber. The piston backing pads

are shown screwed to the die set and U groove is milled into the top pad to accommodate the electrical leads. When the piston is pushed into the cylinder by applying external load at the top of the piston (Fig. 3), the pressure inside the liquid is slowly increased as the load is increased and the liquid in the cylinder may leak through the interface between cylinder and piston walls. This problem of leakage is overcome by having suitable seals, the most popular being the 'O' rings of phosphor bronze followed by neoprene rings. These are fitted into the grooves of the piston. The load, and hence the pressure, are

controlled by controlling the load with the help of a hydraulic system. As the pressure increases so does the resistance of the gauge, which is read on a digital multimeter and then converted into pressure.

This system suffers from the drawback that measurements are possible only at room temperature and above but not below. A heater coil is put into the cylinder from the other end of the cylinder and proper seals are again used to avoid the leakage of the liquid. The temperature is transmitted to the sample through the heated oil and can be controlled by adjusting the power input to the heater. However, using such a system, it is not possible to go beyond $\sim 200^\circ\text{C}$ since the metal parts expand with temperature, thus, posing the problem of leakage of fluid and hence the pressure. The maximum safe operating pressure for such a system is about 15 Kbar since, for higher pressures, the steel used in the system has a bursting tendency.

The choice of the liquid pressure transmitting medium is inevitably a compromise with a number of factors. The liquid used must be a good insulator and chemically non-reactive with the material under investigation. Also the choice of the liquid must rest to a considerable extent on the compressibility, viscosity and the freezing pressure of the medium. A 1:1 mixture of amyl alcohol and castor oil is found to be most suitable for 0Kbar-15 Kbar range of pressure. The crystal size which such systems can accommodate depends upon the size of the piston, but typically it should be about $2 \times 2 \text{ mm}^2$ having a thickness of about $400 \mu\text{m}$. The main advantage of the system is that the measurements can be taken both for increasing as well as for decreasing pressures to check the validity of the data obtained.

For optical measurements, the sample can be illuminated using optical fibres. Light (visible to nearly $2 \mu\text{m}$) can be introduced through a small sapphire window sealed to the piston and by using aluminium foil. The light can be guided to the window by using optical fibres. Either d.c. or fast pulse measurements can be made on the samples suspended in the fluid close to the window. The magnified view of an actual system

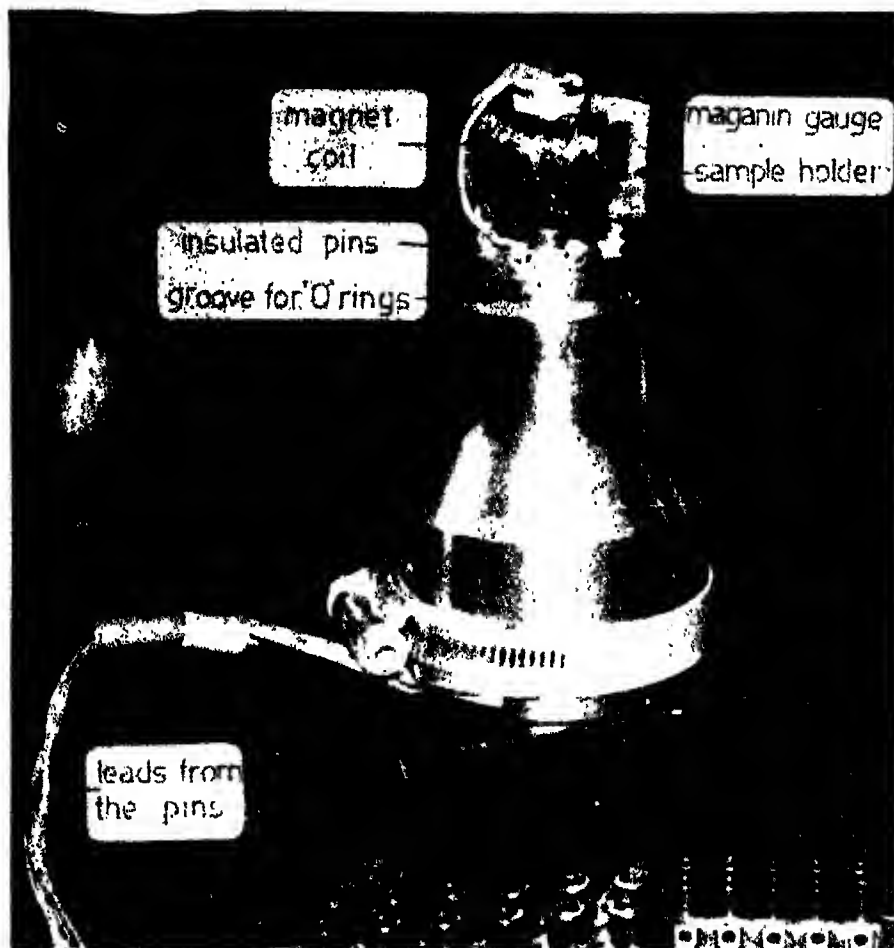


Fig. 2. Photograph of the inverted thrust piston

close to the piston-cylinder assembly is shown in Fig. 3.

High pressure techniques. For transmitting higher pressures (>15 Kbar), liquids cannot be used since most of the oils become hard and water freezes to form ice. The liquid mixture as used in the low pressure gear as described above becomes highly viscous. Hence at higher pressures, the medium is generally a solid rather than a liquid. The ideal solid should have a low shear strength, be chemically inert and not suffer phase changes. There are basically two techniques for pressure generation using solid medium.

Bridgman opposed anvil apparatus (0 Kbar-90 Kbar)

A schematic line diagram of the system is shown in Fig. 4. Pressure is applied to a small area of the anvils surrounded by a larger die assembly so that a higher compressive yield stress of the anvils can be supported.

The anvils are made of high speed tool steel (10% Co). The sample under study is put in a gasket and placed between the anvil faces as shown. This system is calibrated using the known resistance discontinuities for bismuth at 25.4 Kbar and 76 Kbar and for thallium at 76 Kbar. The calibrant is cut to the same size as the crystal to be studied ($\sim 2 \times 2 \text{ mm}^2$ and 0.25 mm thick) and potted in epoxy. The sample resistance is then measured as a function of load and the known resistance discontinuities are observed at critical pressures. Thus, the relation between load and pressure is known.

This system suffers from the disadvantage that measurements above room temperature are not possible. On the contrary, arrangements can be made to lower the sample temperature below room temperature. To lower the temperature of the sample, liquid nitrogen is pumped through copper tubing coiled around the anvils and finally on to the sample through the smaller holes. The copper tubing is insulated by polystyrene discs. By pumping liquid nitrogen continuously, the sample is first cooled down to near the liquid nitrogen temperature (77 K) and the measurements are taken. To do the measurements at higher temperatures (i.e., $>77 \text{ K}$), the flow of liquid

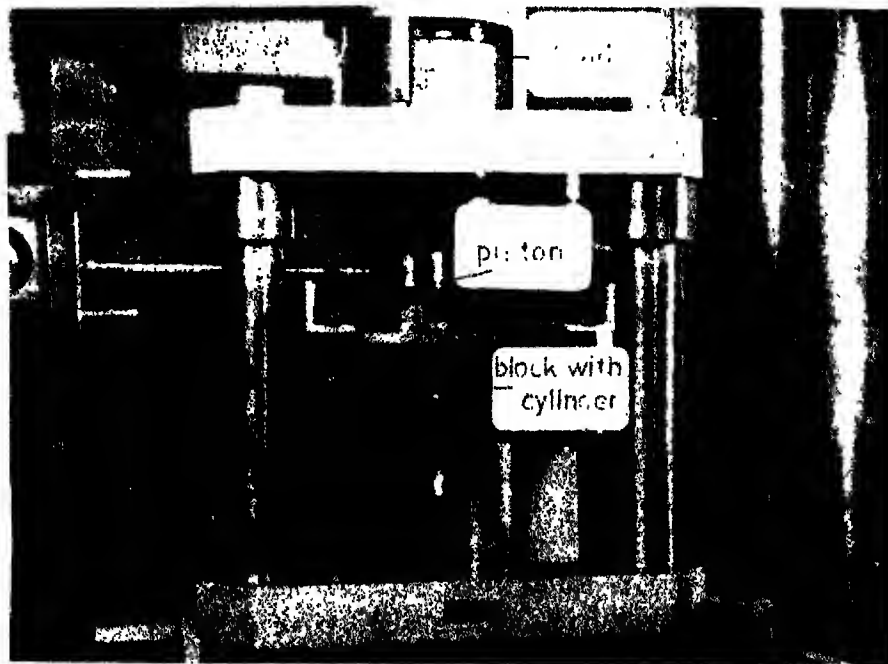


Fig. 3. Photograph of the cylinder-piston assembly in the press

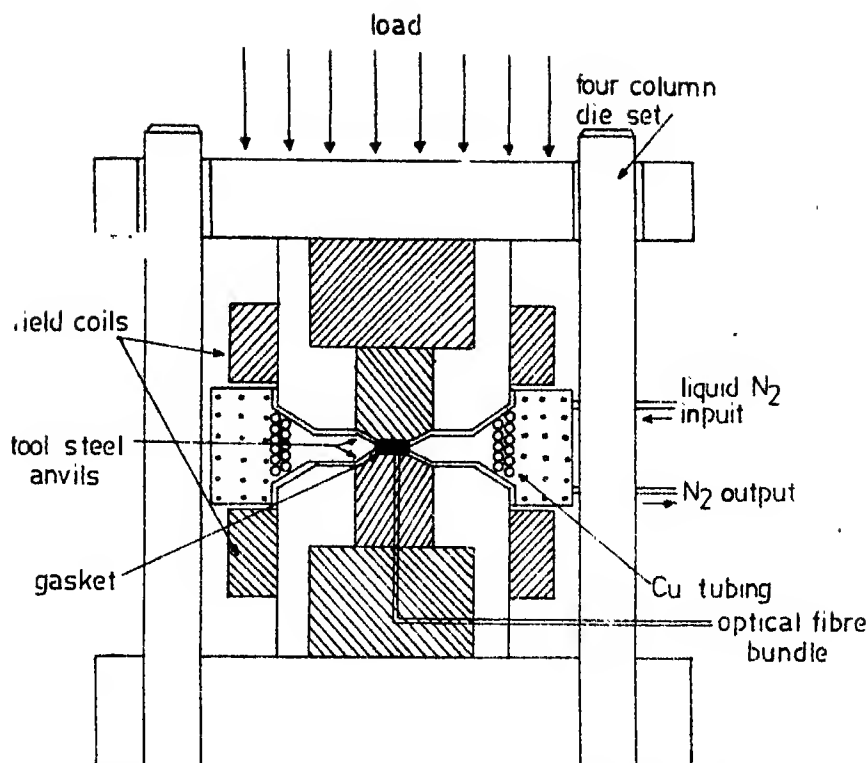


Fig.4 Schematic line diagram of the Bridgman Opposed anvil system

nitrogen is stopped when the system slowly warms up due to the large mass cooled initially and thus facilitates measurements at intermediate temperatures from 77 K to room temperature (~ 300 K). For experiments requiring magnetic field, the anvils are used as magnet poles. Mild steel jackets while providing a little support for the anvils also act as cores for the coils. A mild steel, four column die set completes the magnetic circuit. Sydanlo pads above and below the die set provide magnetic insulation from the press. For optical experiments, an optical path through an optical fibre bundle passing through the lower anvil serves the purpose.

Better mechanical properties and high resistivity ($\sim 10^{12}$ ohm-cm) make the magnesia-filled epoxy an excellent gasket material. The ease of fabrication of Bridgman rings and minimum machining requirements are additional features which make the magnesia filled epoxy a highly suitable material. The PTFE mould and aluminium container are released using silicon resin in an oven. Magnesium oxide is dried and grinded to a very fine powder. The mould is then filled with MgO and placed in an evacuation chamber.

Araldite prepared by mixing epoxy resin, a hardener and an accelerator, is then poured on the magnesia which then penetrates the pores of MgO. When no air bubble is left, the evacuation is stopped and the mould is removed from the chamber and then cured at high temperatures. After curing, the rings are removed from the mould and grinded to about 1.3 mm thickness. When ready, the ring must have an outer diameter of about 13 mm with an inner hole of ~ 4 mm diameter. Grooves (~ 0.5 mm in depth and ~ 1 mm wide) are then cut into one face of the gasket to accommodate the leads from the sample and a thermocouple, if necessary. Fig. 5 shows an enlarged view of a Hall sample potted in epoxy in the gasket.

The gasket with the grooves is placed on a thick mylar sheet and the epoxy made to flow into the central hole and the grooves. The sample is then placed in the hole with the leads resting in the grooves. Under its own weight, the sample and leads are immersed in the epoxy when more epoxy is made to flow to cover the

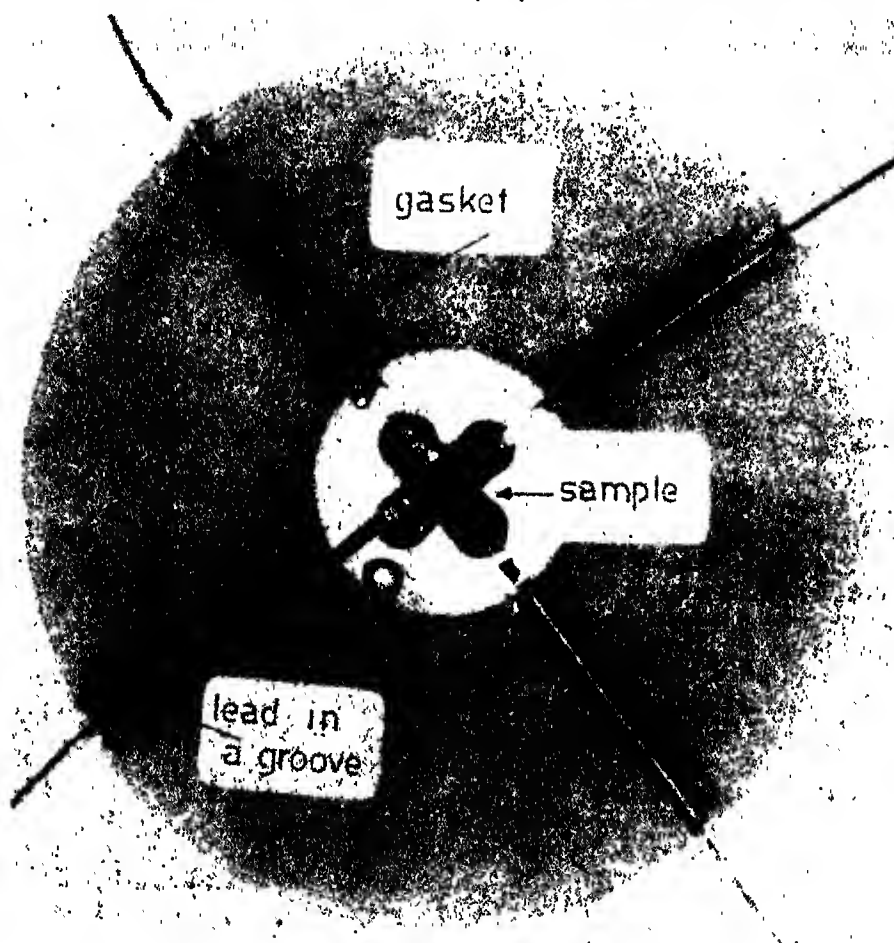


Fig.5. Photograph of the gasket used in the Bridgman system

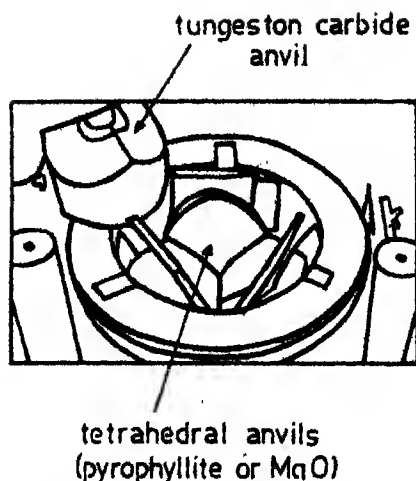


Fig. 6. Line diagram of the tetrahedral anvil system

sample and leads from the top. This ensures complete encapsulation of the sample and leads by the epoxy. Particular care is to be taken to make sure that the sample and leads lie well below the faces of the gasket to avoid breakage of the sample and the short circuiting through the anvil faces when put into the press. No air bubbles should be trapped in the epoxy during sample preparation since they provide stress concentration centres and increase the possibility of fracture of the gasket and sample. Another thick mylar sheet is then placed on the top of the ring and the whole assembly tightly clamped between two flat metallic faces and baked at high temperature to harden the epoxy. After this operation, mylar sheets are carefully removed.

The same press as used with the low pressure system can be used to pressurise the gasket between the anvil faces. As the pressure is increased, the solid epoxy converts itself into liquid and then transmits pressure to the sample. At high pressures, the gasket is locked up between the anvils. If the pressure is now decreased, the gasket expands and therefore, due to stresses developed, the sample and gasket get cracked. Due to this unavoidable difficulty, measurements with lowering pressure are not possible with the system and ultimately, since the system has to be reloaded, the sample breaks. The process is, thus, destructive in nature and the sample cannot be recovered.

Tetrahedral anvil apparatus (0Kbar-100 Kbar)

The tetrahedral anvils resting in a steel collar are shown in Fig. 6 and are made of either pyrophyllite or partially sintered MgO. A fourth anvil made of tungsten carbide sits on top of the tetrahedron. When load is applied, the tetrahedron extrudes between the anvil faces and eventually locks under the high frictional forces to form a gasket. Samples can be placed within the tetrahedron for a variety of experiments. In one typical experiment, a single crystal of BaTiO_3 ($\sim 1\text{mm}^3$) was potted in epoxy resin and a Cu heating element wound around the internal pressure chamber. Wires to the silver contacts

on the sample and the thermocouple next to the sample were then potted in the resin. This enabled accurate temperature excursions upto, 200°C to be carried out at fixed pressures after the sample assembly was placed in a hole drilled in the tetrahedron. The wires and thermocouple pass out of the tetrahedron through the gasket edge. Also a teflon internal cylindrical cell has been used to include liquids within the tetrahedron and relatively large ($\sim 2 \times 2 \times 2\text{mm}^3$) single crystals can now be pressurised to 40 Kbar. Heaters can be placed around the internal sample cell and high currents passed through the anvils to provide temperatures approaching 1500°C .

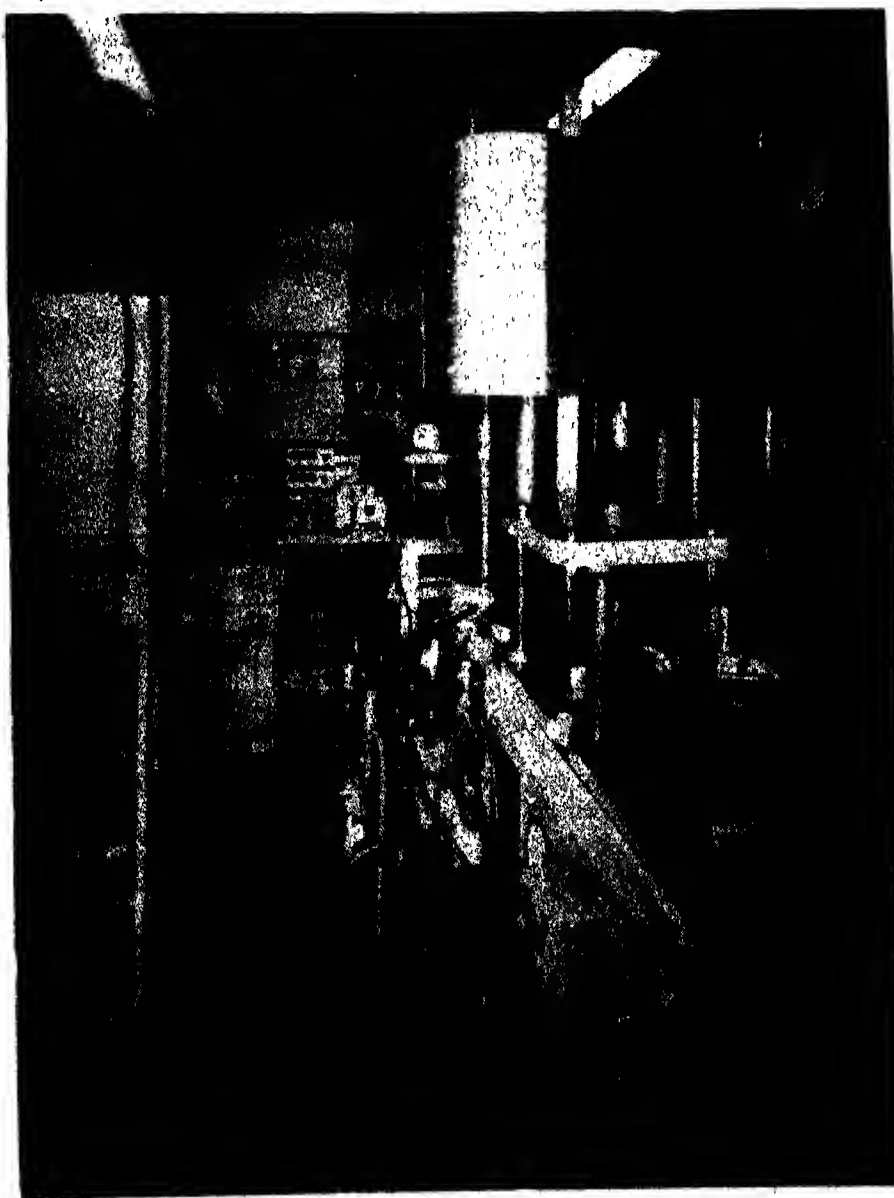


Fig. 7. Photograph of a complete assembly of a pressure generating system

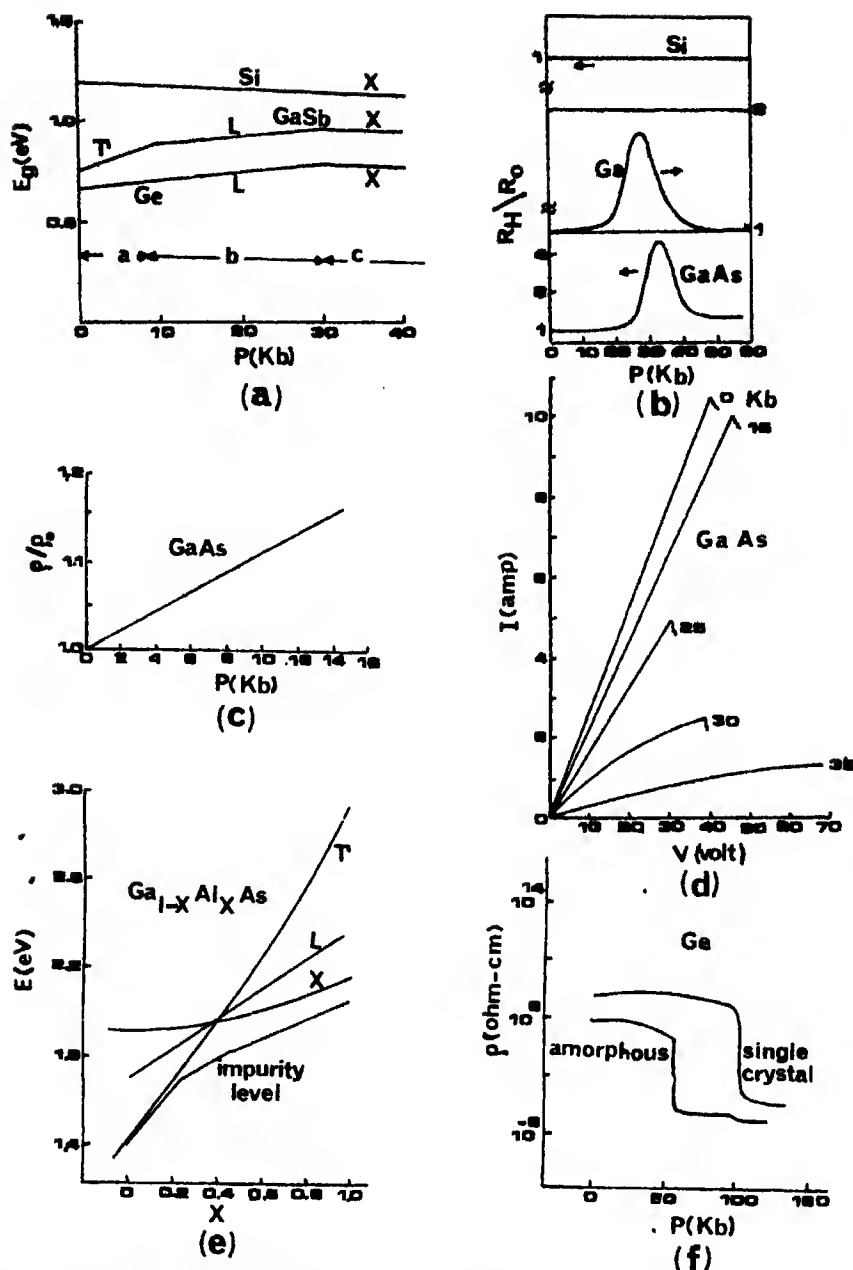


Fig. 8. (a) Energy gap as a function of pressure, (b) Hall constant as a function of pressure, (c) resistivity as a function of pressure for GaAs, (d) Current-voltage characteristics with pressure as a parameter for GaAs, (e) Band structure of $Ga_{1-x}Al_xAs$ alloy system and (f) resistivity as a function of pressure for Ge

The same press as shown in Fig. 3 can be used with this apparatus. A complete assembly of the high pressure system is shown in Fig. 7.

Results

A large number of different kinds of experiments can be performed using high pressure systems and it is impossible to present and discuss all of them here.

To give an idea about the utility of the technique, only some of the properties of Ge, Si, GaSb and GaAs alloy system will be presented in brief.

Fig. 8(a) shows the absorption edge energies as a function of pressure for Ge, Si and GaSb (Pitt 1976). The striking feature of these graphs is that at high pressures (region C), the three curves are almost parallel. Also in region b, the curves for GaSb and Ge

are parallel. It clearly signifies that for these pressure ranges, the conduction band minima involved are the same and move with the same pressure coefficients. This information can be interpreted to obtain the details of band structure and the scattering theories. In Si, the lowest energy conduction band minima are X and surely these have a slightly negative pressure coefficient. In Ge, the lowest energy minima are L and these move with a higher positive pressure coefficient upto a pressure of ~ 36 Kbar after which L minima catch with the X and the coefficient is negative. In GaSb, firstly the minimum catches up quite fast with the L minima near 8 Kbar and thus L and X minima cross at about 30 Kbar after which X minima move with the characteristic negative coefficient. Thus the observation of various pressure coefficients is a good indication of which conduction band minimum is the lowest in energy at atmospheric pressure. The band cross-over effects observed in GaSb allow a determination of the next higher minima, their symmetry and the sub-band energy gaps.

The Hall constant R_H normalized to its atmospheric value is shown in Fig. 8(b) as a function of pressure for Si, Ge and GaAs samples. For Si, R_H is found to be constant upto 70 Kbar and more. This signifies that in Si, the electron transport occurs only through one set (X) of minima. In Ge, R_H increases with pressure and then goes through a maximum at a pressure where the L minima with a positive pressure coefficient catch up with the X minima having a negative pressure coefficient. A similar result is obtained for GaAs and, thus, establishes a multiconduction band structure for it as for Ge (Pitt and Lees, 1970). The pressure techniques have also been used to establish the band structures of a number of semiconductors including GaAs/AlAs mixed crystals (Saxena, 1980).

Fig. 8(c) shows the variation in the resistivity of a GaAs sample (normalised to atmospheric value) as a function of hydrostatic pressure upto 15 Kbar (Vyas, 1974). The variation is linear with a pressure coefficient of $\sim 9 \times 10^{-3}/\text{Kbar}$. This is about 4 times the pressure coefficient of manganin wire ($\sim 2 \times 10^{-3}/\text{Kbar}$) which is also

(Continued on page 84)

EVAPORATION CLIMATOLOGY IN AGRICULTURE

K.K. NATHAN

Measurement of evaporation from land surface is important in agriculture, especially in arid and semi-arid regions where water is the main constraint

THE process of evaporation of water in nature is one of the basic components of hydrological cycle. During evaporation, a liquid changes to gas or vapour. It is the only form of moisture transfer from land and ocean to the atmosphere. Evaporation from natural surfaces like soils, vegetation or plants is a diffusion process in which water in the form of vapour is transferred from the underlying surface to atmosphere. This is possible only when there is a heat source which in this case is solar energy. Optimum vapour pressure gradients should exist between evaporating surface and the atmosphere. Evaporation from land surface is influenced by meteorological factors like wind speed, atmospheric humidity, solar radiation, soil temperature gradients, vegetation, etc. Water is also lost from vegetation as transpiration and it is basically an evaporation process in plants by which water vapour leaves the plant body and enters atmosphere. The combined loss of water by plants as evaporation (E) and transpiration (T) is called evapotranspiration (ET).

Estimation or measurement of evaporation or evapotranspiration is important in agriculture. Scheduling of irrigation, and water management practices are based on evaporation values. This is particularly important in arid and semi-arid regions where water is the main constraint. The regime of evaporation and evapotranspiration during crop growth cycle is of immense interest and importance to agriculturists, hydrologists, agronomists, and climatologists as it helps in planning and

development of their projects relating soil-water-plant-atmosphere system.

Factors affecting evaporation

The major meteorological parameters which affect evaporation rate from a free water surface area are:

- (1) Solar and sky radiation,
- (2) Temperature of the air and of the evaporating surface,
- (3) Wind run,
- (4) Saturated vapour pressure at the water surface and actual vapour pressure of air at that temperature,
- (5) Atmospheric pressure,
- (6) Depth and size of the evaporating surface,
- (7) Impurities in the water body

Like evaporation, evapotranspiration is primarily influenced by various climatic elements. What one needs is a precise measurement of these elements, but most of the devices for measurement are costly. An evaporimeter is a device which could integrate all the climatic effects and is cheap and easy to operate and maintain. In a meteorological observatory, it is installed along with other weather instruments.

Evaporation network in India

Water resources planners may require either monthly or seasonal pan evaporation data. For agricultural operations and water management practices one needs to have weekly values of evaporation. For the sake of uniformity, the World Meteorological Organisation in 1965 recommended a minimum network density of one evaporimeter per 30,000 sq. km. in

arid regions and one such instrument per 50,000 sq. km. In humid regions. However, according to another approach from *Operational Hydrology Report No. 8* (WMO, 1976), a network density of one pan evaporimeter per 10,000 sq. km.-15,000 sq. km. in arid regions and one per 30,000 sq. km. in humid regions was established.

Applying this criteria to the Indian situation, where we have a total area of 3.28 million sq. km., out of which 1.28 m sq. km. lie in arid or semi-arid regions, one pan per 30,000 sq. km. in humid to very humid regions has been worked out. This comes to approximately 200 evaporimeters for the dry pockets, about 43 in wet or humid pockets, totalling about 243 evaporimeters for the entire country. Fig. 1 depicts the location of pan evaporimeter stations controlled by Agricultural Meteorology Division of India Meteorology Department.

Basic equipments for measuring daily evaporation

Instruments for gauging daily evaporation can be classified into two types. (1) open water evaporation pans, and (2) porous type atmometers. These devices are more useful than the various empirical relations used to estimate evapotranspiration of any crop. It has been observed that a close relation exists between water use of crops and rate of evaporation from a well located pan.

The most commonly used open evaporation pan is United States Weather Bureau (USWB) class 'A' pan. The other types are sunken pan,

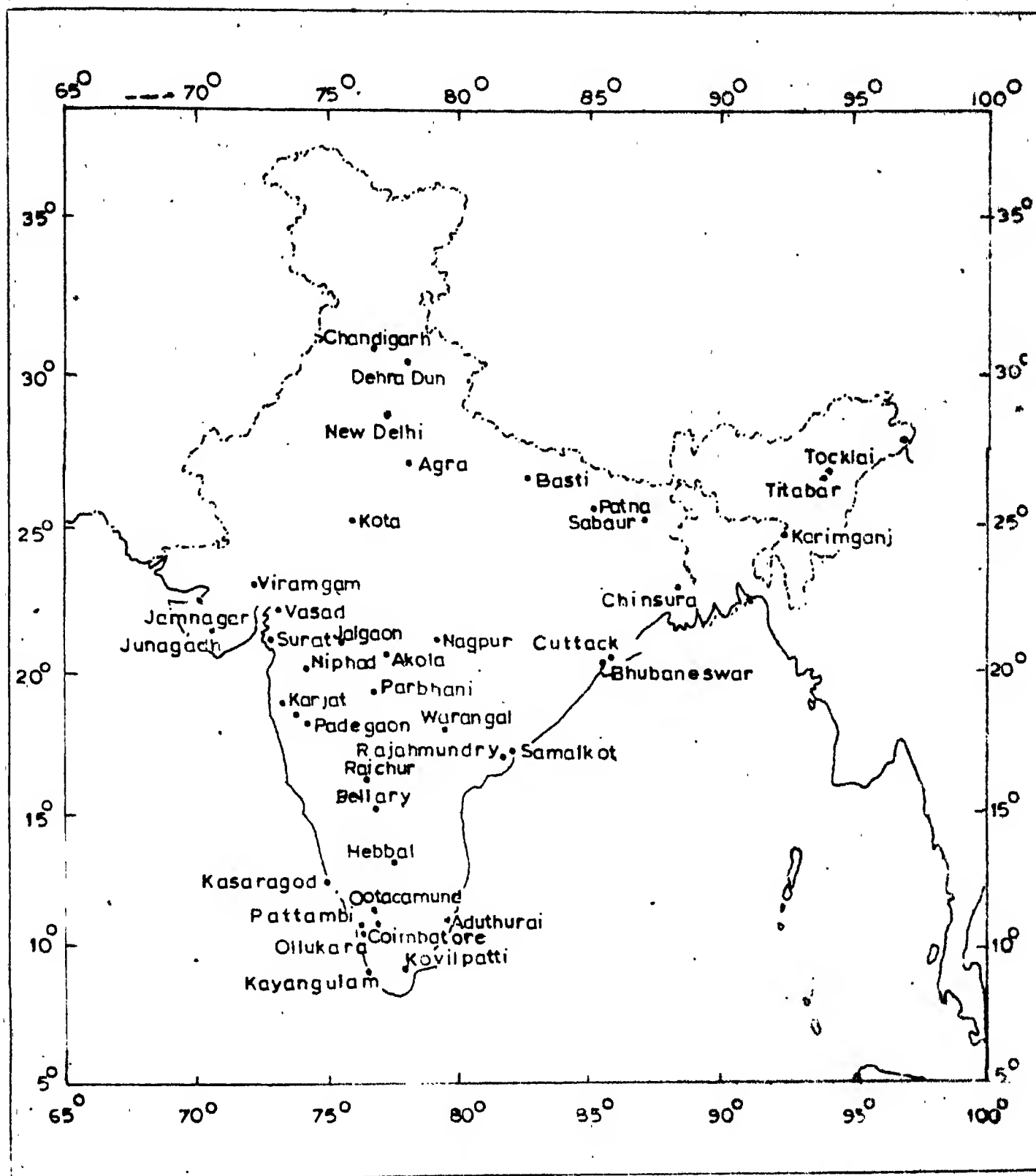


Fig.1. Location of agromet, evaporimeter stations (Source : India Meteorological Department)

sunken screen pan, etc. The standard USWB class 'A' pan is generally made of 20 gauge galvanised iron sheet, 120

cm in diameter and 25 cm depth (Fig.2). It is painted white, both inside, and outside to reflect all radia-

tions and is mounted on a wooden platform about 10 cm above the ground. It is filled with fresh water

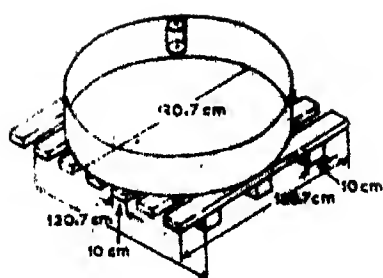


Fig. 2. Class A evaporation pan

upto 5 cm below the rim of the pan and covered with a wire mesh screen (0.8 cm hexagonal mesh) to prevent birds and animals from drinking water. The water level of the pan is read by means of a hook gauge resting over a stilling well. Daily readings are taken both in morning and afternoon. The difference in the observation of any consecutive days gives the evaporation value after adjusting for rainfall, if any.

The rate of evaporation from a pan varies with size, colour, material, depth, exposure, etc. A copper pan is not only costly but also the evaporation loss in it is 5%-10% more than in conventional pans. When the atmospheric humidity is high, evaporation rate is independent of pan size. As and when the weather becomes dry, the size of the pan influences the rate of evaporation. It has been experimentally found that if a pan is painted

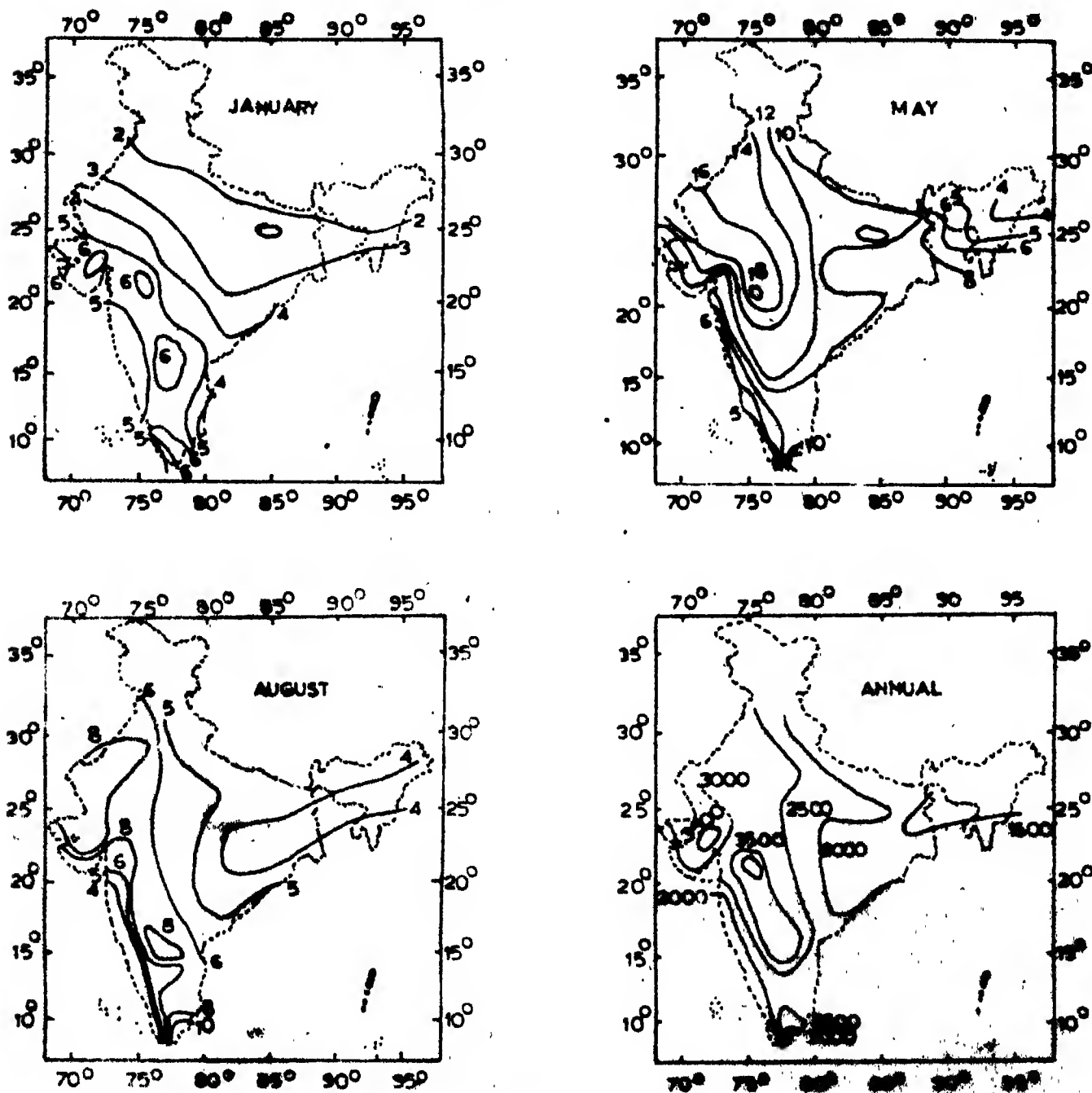


Fig.3. Mean daily and annual evaporation (mm) (Source : IJMG, 1971)

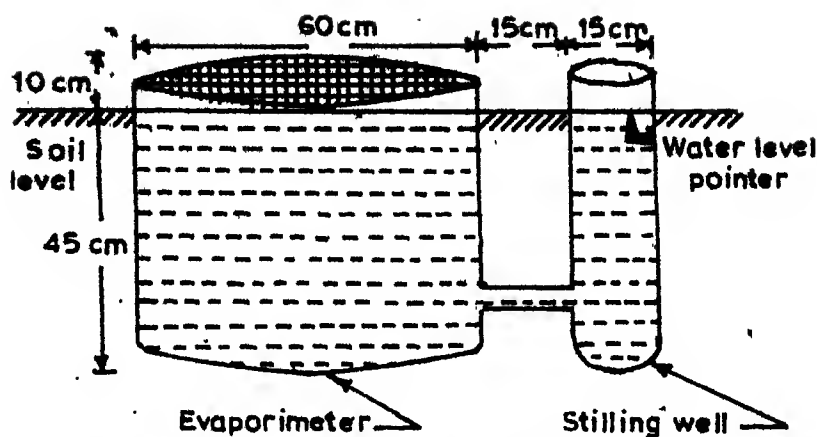


Fig.4. Sunken screen pan evaporimeter (Sharma and Dastane, 1966)

black, the evaporation rate is 23% higher than if it is painted white. Another important aspect of evaporation pan is the height at which it is installed. A pan of 60 cm dia. at a height of 20 cm loses about 12% more water by evaporation than one at the ground level. The same pan loses about 24% more water than the one placed below the soil surface (sunken pan).

Evaporation pattern over India

Fig. 3 represents the seasonal and annual distribution of mean daily evaporation over India. In January which represents the winter season, the evaporation rate is lowest (2mm/day) in northern parts of India. In the southern region during the same season it is about 5mm/day.

In summer, evaporation rate is 14mm-16mm/day in North India. However, the arid pockets like Saurashtra (Kutch) register 18 mm/day during this season. August being the rainiest month due to south-west monsoon current, the evaporation rate is about 4 mm/day except in the dry pockets of Tamil Nadu where it is



Fig 5

10 mm/day. On annual basis, arid zones of Saurashtra and some pockets of Tamil Nadu record about 3000 mm to 3500 mm of evaporation. For the country as a whole, the annual value ranges from 1500 mm to 3800 mm.

There is a striking relationship between diurnal pattern of transpiration and evaporation from a shallow pan. The results of previous studies show that evaporation data could be effectively used to estimate ET for vegetation. The ratio of ET/E is highly dependent on the type of pan or tank. The average ratio is 0.8 for USWB class 'A' pan and 1.05 for a standard Australian evaporation tank.

Sunken pan

Sunken pan is considered to be more representative of ET of crops than class 'A' pan. Fig. 4 depicts a sunken pan developed by R.G. Sharma and N.G. Dastane (1968) at IARI, New Delhi. It consists of an evaporating pan, a stilling well and a connecting tube. The evaporimeter is 60 cm in diameter, 45 cm in depth and is made of 20-gauge galvanised iron sheet. It is painted white on all sides. The stilling well is 15 cm in diameter and 45 cm in depth. It has a pointer attached to the side wall and bent upward at right angle at the centre. It is installed by digging a pit of suitable size so that the pan could be fitted in and back-filled with earth with adequate compaction. Usually the edge of the pan is kept 10 cm above the ground level. The method of observation is similar to that of class 'A' pan.

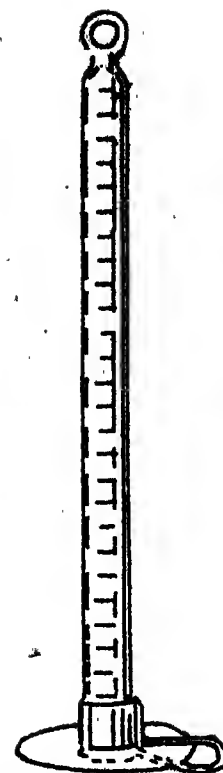


Fig. 6. Piche atmometer

Atmometers

Atmometers are devices for gauging the rate of evaporation of water. The sensors are either a porcelain body of porous paper. Fig. 6 depicts a piche atmometer. It consists of a cylindrical graduated glass tube 30 cm long and of 15 cm diameter with one end open. The tube is filled with distilled water and turned upside down. The open end of the instrument contains a filter paper as sensor with a clip. The water in the tube wets the paper and evaporation takes place. In this instrument, the rate of evaporation is greater than with class 'A' pan or sunken pan. Also, it gives a poor correlation of evaporation rate with ET. It tends to overestimate the wind effect and underestimate the radiation values. The pores of the filter paper easily get clogged with dust and salt. However, if one can take due precautions it can be used to study the micro-climate or bio-climate of the environment.

The pan evaporimeter is a useful gadget for farmers. It can be set up at low cost and does not involve much labour to instal. However, while choosing site one should see that

there is no obstruction near its vicinity and the terrain is horizontal. The daily pan evaporation rates can give valuable clue to agriculturists for irrigation scheduling.

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HIGH PRESSURE TECHNIQUES (Continued from page 79)

used as a pressure sensitive device. There are also other compounds like GaAs/AlAs alloys which show a pressure sensitivity as high as 200 times that of the manganin gauge (Saxena, 1982).

Fig. 8(d) shows how the threshold field for GaAs GUNN device varies as a function of pressure. Each curve is a current voltage plot of a two contact device at different pressures (Pitt 1976). When the bands are close together at high pressures, the oscillations cease when eventually all the electrons occupy the X states. From such data, it is possible to make an estimate of the position of the L minima in GaAs which are also involved in the scattering process at high fields. Calculations are now possible to determine the ultimate efficiency of such devices and thus rapidly indicate whether costly materials work should proceed or not.

The ternary semiconductor compounds are highly versatile for use in optical devices. To predict the device performance, it is necessary to know the details of their band structure. This is very expensive since a lot of material with different compositions must be grown. It has been shown that the alloy composition is equivalent to pressure. Hence, the complete band structure of the alloys can be determined from a single pressure experiment and, thus, a complicated series of growth experiments can be avoided (Saxena 1980).

The band structure of $Ga_{1-x}Al_x$ As alloys thus determined is shown in Fig. 8(e). The same technique may be used to know the alloy composition of $GaAs_{1-x}Px$ alloy laser diodes at which the efficiency drops to a very low value because of the indirect nature of the band gap (Pitt, 1976).

Let us now see an example of phase transition at high pressures. Fig. 8(f) shows the variation in the resistivity for a single crystal Ge and also for amorphous Ge (Pitt, 1976). At about 100 Kbar, there is a sharp drop in the resistivity of single crystal Ge due to phase transition from a diamond type structure to white tin type structure which has metallic properties and, therefore, much lower resistivity. Transitions of this type can be used to calibrate the pressure cells. The phase transition in amorphous Ge takes place at a much lower pressure (~60 Kbar). This can be interpreted since amorphous Ge has a much closer packing of atoms than single crystal Ge and, therefore, the critical pressure for phase transition drops to a lower value. Such studies are very useful in establishing crystal structure of solid state materials.

Conclusion

Various techniques for applying hydrostatic pressure to tiny crystals of solid state materials have been described together with the sample preparation wherever necessary. The impact of such techniques in investi-

gating the structure, optical and electronic properties of some materials has also been discussed in brief.

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TRANSITION ELEMENTS IN BIOLOGICAL SYSTEMS

It is now well established that life in its present form would not survive without the presence of minute traces of some of the transition elements

P.C. NIGAM
S.B.S. MISRA

EVEN two decades back, biochemistry was thought to be only an elaborate branch of organic chemistry because of the fact that proteins, carbohydrates, lipids and fats could be dealt with by organic chemists in a better way. The amounts of minerals and trace elements in biological systems are so meagre that their presence was almost ignored for a long time. The invention of modern analytical techniques enabled analysts to detect and estimate the presence of many transition elements in biological systems. The detection itself was a tedious task because the amount of these elements was so small that it was like searching a needle in a haystack. If we take the average weight of a person as 70 kg, the approximate amounts of essential elements present would be as given in Table 1.

It is now well established that life, at least in its present form, would not have been possible in absence of trace elements listed in Table 1. They have been shown to be essential for important biological functions like the dioxygen binding and transport, electron transfer, substrate binding and catalysis. In all these functions one metal ion or more is the centre for the performance of some vital role. Transition elements by virtue of their inherent properties are well suited for these functions and therefore nature has perhaps chosen them very judiciously.

With increasing knowledge of the role of trace elements in biological

systems, a separate branch of chemistry known as bioinorganic chemistry has emerged. It has brought biologists, microbiologists, chemists, physicists and medical men on a single platform in an endeavour to enlarge our understanding of the role of trace elements in biology and medicine.

Role of transition elements

It is interesting to note that nature has incorporated mainly the elements of first transition series. The one exception is molybdenum and it is the only element known to be present in biological systems from amongst the second and third series of transition elements. The main role of the transition elements in biological systems will now be discussed.

(a) *Titanium*. There is no evidence that titanium plays any vital role in biological systems. It is poorly

absorbed by plants and animals. The level of titanium in tissues is much lower than in the environment but it does reflect environmental exposures.

(b) *Vanadium*. The human body contains about 10mg-25 mg of vanadium in bones, teeth and fat. Its presence inhibits cholesterol synthesis and perhaps it is beneficial to teeth. Vanadium is essential for the growth of fungi and green algae but its essentiality for higher plants is not yet certain. Although vanadium is not very toxic to human beings, it has been shown to be toxic to rats at a dietary concentration as low as 25 ppm.

(c) *Chromium*. It is widely distributed in human tissues. In plasma it is bound to the transferrin component of the β_2 -globulin fraction. Its biological function is dominated by Cr^{+3} state. This ion forms octahedral complexes stable at pH 4 or less.

Table 1. Amounts of elements present in a 70 kg human body

A. Metals		B. Non-metals	
Element	Amount (gm.)	Element	Amount (gm.)
Na	70	H	6580
K	250	C	12,590
Mg	42	N	1815
Ca	1700	O	43,550
Mn	1	P	680
Fe	6	S	100
Co	1	Cl	115
Ni	1	I	1
Cu	1		
Zn	1-2		
Mo	1		

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Though hexavalent chromium is better absorbed than its trivalent state, the former is more toxic than Cr^{+3} . Exposure to high chromium levels has been held responsible for lung cancer in man and liver and kidney damage in animals. Wheat leaves contain about 4 ppm-6 ppm of Cr but most plants contain less than 1 ppm. There are numerous reports on toxic effects of Cr on plants.

(d) **Manganese.** It is an essential element for animals and plants. In human body its amount ranges from 12mg-20mg. One well-known metalloprotein containing Mn is pyruvate carboxylase. Manganese has been shown to play a vital role in photosynthesis. Its deficiency causes gonadal dysfunction and skeletal deformation. It is believed that Mn is the least toxic of all the trace elements; yet excess metal condition causes ataxia. Chronic Mn poisoning has been reported to occur among miners.

(e) **Iron.** It is a very important element for both plant and animal kingdom. More than 50 iron proteins are known at present. Their number is increasing. These iron proteins may be broadly classified as (i) Iron transport and storage proteins and iron proteins containing labile sulphide groups, (ii) Iron flavoproteins, and (iii) Iron porphyrin proteins or haemoproteins. Its important oxidation states are two and three. Human body contains about 4g-5g or 60 ppm-70 ppm of iron. Most of this is in complex forms bound to proteins either as porphyrin or haem compounds (particularly haemoglobins and myoglobins) or as non-haemoproteins such as ferritin and transferrin. Haemoglobin plays a pivotal role in all animals and about 60%-70% of body iron in man is incorporated as haemoglobin. Its role in respiration by reversible binding of dioxygen has been extensively investigated. The highest concentration of iron is present in liver, spleen, kidney and heart. Deficiency of iron causes many diseases including anaemias. However, prolonged administration of iron containing drugs has been found to be harmful and may cause haemochromatosis and siderosis.

(f) **Cobalt.** Cobalt is unique among trace elements in that it is biologically

active in higher animals only when it is incorporated in the corrin ring as in vitamin B₁₂ or as one of the cobalamide derivatives. The essentiality of Co for blue-green algae, green algae and some bacteria and fungi has been well established. Some positive response in growth and yield has been correlated with the presence of cobalt in higher plants. While cobalt deficiency has been shown to cause anaemia, a higher input in human body can cause polythemia and coronary failure.

(g) **Nickel.** Nickel occurs in both animal and plant tissues. The existence of metalloproteins in human serum rich in nickel and which contain other trace metals was first reported in 1966. The observation led to speculation about the essential physiological role of nickel although the specific role has not yet been asserted. It was earlier believed that nickel has a low toxicity for several species and that nickel contamination does not cause a serious health hazard to man. Recent investigations however have shown that excess metal condition may result in leucocytosis and coronary failure. On the other hand, deficiency of nickel has been proved to cause tertiary anaemia and retarded growth.

(h) **Copper.** Copper is a functional constituent of all cells. That is why there is a direct correlation between copper concentration and cellular activity. The normal range of copper in human body is between 100 mg to 150 mg and normal adults require about 2 mg of copper intake every

day. At least thirty copper containing proteins and enzymes have been reported. They include ceruloplasmin, ceruloplasmin, erythropoietin, and haemocuprein, which are among some essential mammalian copper proteins. An important feature of copper enzymes is their ability to use molecular oxygen directly. A delicate balance of copper is necessary, even a slight increase or decrease in copper concentration may cause severe internal disorders. Copper deficiency in animals results in inhibition of cytochrome oxidase activity and gives rise to kinky hair syndrome and secondary anaemia, whereas excess of copper causes copper toxicity leading to ailments like cataract and Wilson's disease.

(i) **Zinc.** The human body contains about 1.4g-2.3g of zinc. This is about half the amount of iron present. Male sex organs have a high concentration of zinc. Zinc is required for the activity of several enzymes and is involved in the RNA and protein synthesis. It is implicated in the production and functioning of several hormones. Zn has been proved to be essential for higher plants, bacteria, fungi, green algae and blue-green algae. Deficiency results in the decreased activity of various zinc containing and zinc dependent enzymes causing hypogonadism and dwarfism. Exposure to zinc vapour has been shown to cause what is known as metal fume fever.

(j) **Molybdenum.** This metal has a profound effect on copper metabolism. Xanthine oxidase in animals and nitrate reductase in plants are well-

Table 2

(Continued on page 112)

Trace element	Deficiency symptoms	Excess metal symptoms
Vanadium	Skeletal defects, reproductive failure	Inhibition of ribonuclease
Chromium	Corneal opacity	Lung cancer, liver & kidney damage
Manganese	Skeletal & cartilage defects, Gonadal dysfunction, reproductive failure	Ataxia
Fe	Blood disorders, anaemias	Haemochromatosis siderosis
Co	Anorexia, anaemia	Polycythemia coronary failure
Ni	Perinatal mortality, retarded growth	Leukocytosis, coronary failure
Cu	Cardiac disorder, skeletal & vascular defects, anaemia and kinky hair syndrome	Wilson's disease
Zn	Anorexia, foetal malformation, Perinatal mortality, drawflam	Metal fume fever
Mo	Defective keratinisation	Gout

EVOLUTION OF GENETIC LANGUAGE

The establishment of a genetic language which exist in all life forms possibly came about as a result of specific stereochemical relationship between nucleotide triplets of RNA and amino acids

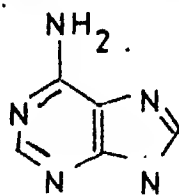
**SHAMIMA ANSARI
MASOOD AKHTAR
MUJAHID A. KHAN**

TODAY we see various forms of life which differ in their shape, size and organisation. Many of them are visible to the naked eyes while others are so small that we cannot apprehend them. However, the essence of life in all these forms is essentially the same. They are endowed with two characters, namely, the ability to transfer and transform energy in a directed way and the ability, having learned this process once, to remember and transfer it from one generation to the next. These properties are primarily associated with two biopolymers, the protein for the energy conversion process and the nucleic acid for the information transfer process (M. Calvin, 1964: University of California, Berkeley, U.S.A.). In fact, different life forms can be considered as various efficient thermodynamic systems which nature has preserved ingeniously during the course of biological evolution. Nucleic acids played a pivotal role in accomplishing continuity of life. They are capable of transmitting and storing information from one cell (unit of life) to the other by means of their nucleotide sequences (the building blocks of nucleic acids) which, in turn, determine amino acid (monomers of proteins) arrangements in cell proteins.

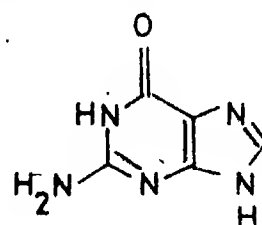
Units of nucleic acids are nucleotides. These monomers are a complex of three molecules, namely, phosphoric acid, pentose sugars (D-deoxyribose and D-ribose) and the nitrogen bases (purines and pyrimidines).

Purines include adenine (A) and guanine (G) (Fig. 1), while cytosine (C), thymine (T) and uracil (U) come under pyrimidines (Fig. 2). A purine always pairs with a pyrimidine and *viceversa*. The pairings are A=T or U and G=C which are stabilized by two and three hydrogen bonds respectively. The two adjacent nucleotides in a nucleic acid molecule are stacked by phosphate diester bond and constitute 5' and 3' ends of the molecule (Fig. 3). There are two species of nucleic acid, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

DNA contains D-deoxyribose sugar and all nitrogen bases except uracil. It is a double helical structure of polynucleotide chains running anti-parallel to each other where purine and pyrimidine remain to the inner side of the molecule in their complementary fashion, leaving phosphate-sugar backbone to the outer side (Fig. 3). DNA stores and transfers hereditary information of the cell. In addition, it creates its own replica and so maintains the biological system generation after generation.

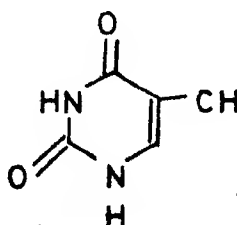


ADENINE

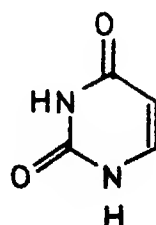


GUANINE

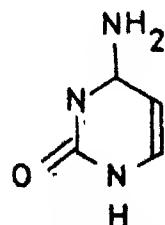
Fig. 1. Purines



THYMINE



URACIL



CYTOSINE

Fig. 2. Pyrimidines

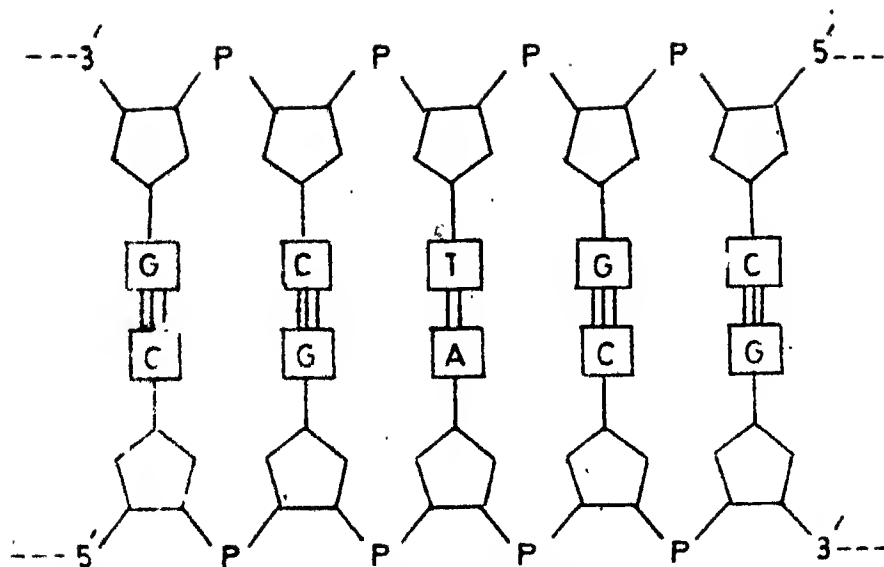


Fig 3 A portion of DNA

complementary nucleotides for pairing with codon of mRNA during the synthesis of protein. All tRNAs differ widely in their nucleotide sequence which enables the aminoacyl-tRNA synthetases to recognise each tRNA and match it with the proper amino acid on 3' terminus of the molecule. The enzyme has two recognition sites one for an amino acid and the other for its corresponding tRNA. Hence, it increases fidelity of protein synthesis by identifying correct combination. Now, the amino acid-tRNA complex becomes ready to enter the ribosomes for the synthesis of protein. The ribosome promotes accurate codon-anticodon pairing and causes successive codons to be read and the corresponding amino acids to be covalently linked with

RNA is composed of D-ribose sugar and also possesses all nitrogen bases except thymine (only tRNA contains thymine). It constitutes several subspecies, viz., mRNA, tRNA and rRNA. mRNA is a single strand of polynucleotide chain. It carries the stored information of DNA for translation into various proteins. Therefore, it serves as a blueprint for the biological system. The blueprint (mRNA) expresses each amino acid in a language of four alphabets (nucleotides) which has the vocabulary of sixty-four words (codons). Each word is represented by three alphabets and the language is called "genetic code". All these codons specify 20 L-amino acids (Table 1). The particular arrangement of the codons in a blueprint embodies amino acid sequence of the desired protein.

Mechanism of protein synthesis

The codons of a blueprint are decoded with the help of tRNA, aminoacyl-tRNA synthetase and ribosomes. Of these, tRNA acts as a vehicle for transferring free amino acids into assembled chains of proteins. Each tRNA assumes a three dimensional clover leaf-like (L-shaped) structure containing dihydrouridylic (DHU), anticodon, variable and pseudouridylic (TΨU) loops as well as an acceptor arm. Acceptor arm contains CCA sequence of nucleotides at the 3' end of all tRNAs for amino acid attachment. Anticodon loop has three

Table 1. The code word dictionary

		2				U ³
		U	C	A	G	
1	U	Phe	Ser	Tyr	Cys	U
		Phe	Ser	Tyr	Cys	C
		Leu	Ser	Ochre (End)	End	A
		Leu	Ser	Amber (End)	Trp	G
	C	Leu	Pro	His	Arg	U
		Leu	Pro	His	Arg	C
		Leu	Pro	Gln	Arg	A
		Leu	Pro	Gln	Arg	G
	A	Ile	Thr	Asn	Ser	U
		Ile	Thr	Asn	Ser	C
		Ile	Thr	Lys	Arg	A
		Met (Initiation)	Thr	Lys	Arg	G
	G	Val	Ala	Asp	Gly	U
		Val	Ala	Asp	Gly	C
		Val	Ala	Glu	Gly	A
		Val	Ala	Glu	Gly	G

5' Reading 3'

each other. Therefore, it receives genetic information and translates it into proteins. Ribosomes are complexes of RNA and proteins and can be separated in two subunits, i.e., small and large. Small subunit provides spaces for accommodation of tRNA and mRNA simultaneously and helps in correct reading and translocation of codons. On the other hand, large subunit contains peptidyl-transferase which undertakes the addition of amino acid to the growing chain of protein.

In brief, all these molecules are oriented in the main stream of all life processes in such a way that a cycle is setup that manufactures various proteins as and when needed. These proteins exist and work together in an integrated system which constitutes life.

Various theories

The preceding discussion clearly establishes a correlation between nucleotide sequence and amino acid. How did nature establish this relationship? Though many biochemists like C.R. Woese (*Proc. Natl Acad Sci. U.S.*, **54**, 71, 1965), T.M. Sonneborn [*In Evolving Genes and Proteins* (V. Bryson and H.J. Vogel, eds.), p. 377, Academic Press, New York, 1965], A.L. Goldberg and R.E. Wittes (*Science*, **153**, 420, 1966) and J.C. Lacey and K.M. Pruitt (*Nature*, **223**, 799, 1969) paid considerable attention to the issue, none could fully explain it because there are numerous experimental limitations. For instance, we cannot create exactly the same prebiotic environment in the laboratories (that was prevalent during the synthesis of genetic apparatus. Most of the views advanced in this direction are therefore based on speculations and logical interpretations of the structural and functional behaviours of these molecules. There are two schools of thought regarding the evolution of genetic language. One holds that there is a stereochemical relationship between three nucleotide sequences (codon) in mRNA and amino acid. It also advocates the existence of the same genetic code since its origin. In 1965, S.R. Pelc of Medical Research Council, Biophysics Research University, London, showed a schematic correlation between codons and dif-

ferent amino acids. He deduced that codons containing U or C in second place specify all hydrophobic amino acids, the molecules frequently end in a methyl group (CH_3). Those with branched methyl groups are in the U column; OH-groups are seen in the C column. The acidic and basic amino acids have A or G as the second base. Moreover, simple changes in the structure of an amino acid are accompanied by a change of only one base in the codons (Table 2). Conversely, transformations involving a more complicated rearrangement of an amino acid molecule usually involve more than one step for the change in the codon, e.g., valine to methionine. In the subsequent year, S.R. Pelc and M.G.F. Welton of Biophysical Research University, London, constructed molecular models representing nucleotide triplets and their corresponding amino acids. They inferred that such a logical arrangement cannot arise by chance, but there was a definite stereochemical relationship between nucleotide triplets and amino acids which led to the evolution of genetic code into its present form. F.H.C. Crick (1967) of Cavendish Laboratory, U.K., inspected and pointed out some drawbacks of these molecular mod-

els. One of the defects was that all the polynucleotide sequences had been built backwards, e.g., their AAG for lysine was in fact GAA (which codes for glutamic acid). Therefore, he concluded that these models were stereochemically unacceptable. P. Dunnill (1966) working at Botany Department of University College, London, established the stereochemical relationship of anticodons and amino acids in which van der Waals' forces (weak forces of attraction that bring the interacting molecules sufficiently close through hydrogen atom bridging) stabilize amino acids in trinucleotide pockets. He inferred that interaction of anticodon and amino acids might have evolved through a selection by steric restriction rather than by the formation of a chemical complex with trinucleotide. This conclusion is based in part on the use of isoleucine codon (AUA) as a model for a putative methionine codon (AUA). Therefore, it would be premature to put this hypothesis forward as a general one.

The other view postulates that the existing genetic language may be derived from a primitive code which was able to specify only a few amino acids. F.H.C. Crick of Cavendish Laboratory, U.K., discussed the

Table 2. Correlation of a structural difference of an amino acid with change of codon

Amino acid-I	Change	Amino acid-II	Codon changes	
			From	To
Gly	CH_2	Ala	GGU	GCU
Ala	O	Ser	GCU	UCU
Ala	$\text{CH}_2 - \text{C} - \text{H}$	Val	GCU	GUC
Ala	COO^-	Asp	GCU	GAU
Asp	CH_2	Glu	GAU	GAA
GLU	$-\text{OH}$	Gln	GAA	CAA
	$+\text{NH}_2$			
Asp	$-\text{OH}$	Asn	GAU	AAU
	$+\text{NH}_2$			
Val	CH_2	Leu	GUU	GUU
Val	CH_2	Ile	GUU	AUU
Ser	Benzene	Tyr	UCU	UAU
Ser	$-\text{OH}$	Phe	UCU	UUU
	$+\text{Benzene}$			
Ser	$-\text{OH}$	Cys	UCU	UGU
	$+\text{SH}$			
Ser	$-\text{OH}$	Trp	UCG	UGG
	$+\text{Indole}$			
Tyr	$-\text{Benzene OH}$	His	UAU	CAU
	$+\text{Imidazole}$			
Ser	CH_2	Thr	UCU	ACU

hypothesis at length before a meeting of British Biophysical Society on December 20, 1966. According to him, the primitive system would not need all 20 amino acids, a system of 4 or 6 amino acids would have been sufficient. The system was likely to be connected with nucleic acid replication, but the sequence of the nucleic acids had to be right. This would probably have come about by chance and the present code presumably came into existence in three phases.

1. The primitive code in which a small number of amino acids were specified by a small number of triplets.
2. The intermediate code in which the primitive amino acid took over most of the triplets of the genetic language in order to reduce non-sense triplets (which do not code any amino acid) to the minimum. The codons produced by this process for any one amino acid were likely to have been related.
3. The final code, as we have it today, might be operated to minimize the damaging effects of present day mutations (shifting, addition or deletion of nucleotide/nucleotides) in the nucleic acid molecule on individual proteins.

Later in 1973, T.H. Jukes of Space Science Laboratory, University of California, U.S.A., elucidated this view after examining the nucleotide sequence of anticodon loop of tRNA as well as codon-anticodon interactions. He suggested that ancestral code might specify only 10 amino acids, namely, leucine and valine with hydrophobic side chains; the "helix breaker" proline; the two simple amino acids, alanine and glycine; histidine, which binds substrates and prosthetic groups; aspartic and glutamic acids, the acidic pair; a basic amino acid ornithine, and glutamine which is somewhat hydrophilic. The expansion of this code gave rise to an intermediate genetic language for eighteen amino acids by the suppression in 3'-1' pairing of codon and anticodon nucleotides, between G and U and *vice versa*. Further expansion established the modern genetic code which could accommodate 20 amino acids. Moreover, ornithine might have been replaced by arginine during the course of evolution (Table 3). How-

ever, these models pose a problem; why does not an intermediate genetic code occur in any form of life? In this context, he suggested that a single species of organism, possessing the present code, displaced all other forms equipped with primitive genetic apparatus and proceeded by divergent evolution, marked by gene duplication, allopative speciation and natural selection to give rise to various existing forms of life.

No doubt, these models reveal an affinity between nucleotide triplets and amino acids, however, they do not explain evolution of entire genetic machinery as it exists today. Recently, M. Eigen and his colleagues at the Max Planck Institute for Biophysical Chemistry in Göttingen, W. Germany, advanced the "Quasispecies and Hypercycle Theory" by using virus Q as an experimental tool for building of their model. According to this theory, non-instructed RNAs

were synthesized from the free nucleotides in the presence of certain chemical catalysts during prebiotic era. These RNAs produced their enormous copies which differed in their nucleotide sequence. The competition for "food" (energy-rich monomers) resulted in the "survival" of the RNA sequence that was best adapted to the prevailing conditions, which they called the master sequence, together with a "comet tail" similar sequence (erroneous molecules) derived from the master sequence by mutation. The master sequence had the most favourable combination of copying fidelity, stability and replication rate. Existence of the master sequence, together with a huge swarm of mutants derived from it, was called "quasispecies". They also calculated the threshold value for the stable replication of a genetic message. It ranged from 50 to 100 nucleotides which was similar to

Table 3. Changes in ancestral code leading to present code for ten amino acids

Codons		Codons		Codons		Codons	
(i) Ancestral code for ten amino acids							
UUN	Leu	UCN	Pro	UAY	His	UGN	Arg (Om)
				UAR	Gln		
CUN	Leu	CCN	Pro	CAY	His	CGN	Arg (Orn)
				CAR	Gln		
AUN	Val	ACN		AAY		AGN	
GUN	Val	GCN	Ala	GAY	Asp	GGN	Gly
				AAR			
				GAR	Glu		
GUN	Val	GCN	Ala	GAY	Asp	GGN	Gly
				GAR	Glu		
(ii) Changes in (i) leading to code 2 as a result of enzymatic modification of tRNA base 40 and consequent suppression of U—G pairing							
UUY	Phe	UCN	Ser	UAY	Tyr	UGN	Cys
UUR	Leu			UAR	C.T.		
CUN	Leu	CCN	Pro	CAY	His	CGN	Arg (Om)
				CAR	Gln		
AUN	Ile	ACN	Thr	AAY	Asn	AGN	Ser
				AAR	Lys		
GUN	Val	GCN	Ala	GAY	Asp	GGN	Gly
				GAR	Glu		
(iii) Changes in (ii) leading to present code as a result of reassignment of tRNAs							
UUY	Phe	UCN	Ser	UAY	Tyr	UGY	Cys
UUR	Leu			UAR	C.T.	UGA	C.T.
						UGG	Trp
CUN	Leu	CCN	Pro	CAY	His	CGN	Arg
				CAR	Gln		
UAY	Ile	ACN	Thr	AAY	Asn	ACY	Ser
AUA	Ile			AAR	Lys	AGR	Arg
AUG	Met						
GUN	Val	GCN	Ala	GAY	Asp	GGN	Gly
				GAR	Glu		

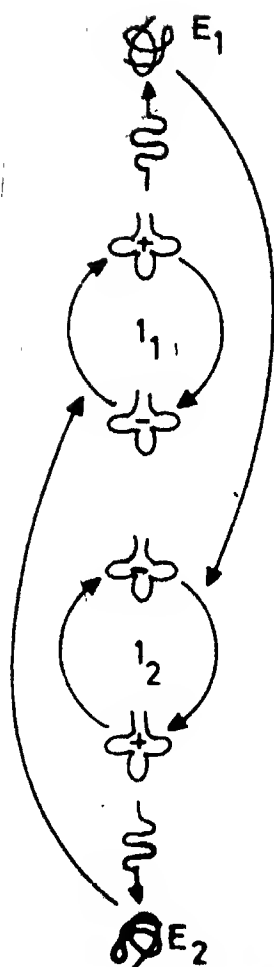


Fig. 4. A schematic representation of hypercycle coupling, an information-carrying RNA (1₁) codes for a primitive enzyme (E₁) that helps to replicate another RNA (1₂), which similarly helps for 1₁ replication through its translational product (E₂)

the size of today's tRNA. The threshold limit was attainable only by RNA sequences rich in G and C nucleotides. Stability of a quasispecies therefore depended upon how much its master sequence competed with its mutant and obeyed the threshold law so that errors might not be accumulated. However, it was too short for a genetic message to encode a functional protein. The limit was eventually overcome by the development of a capability for the translation of genes into proteins, and so of enzyme machinery that reduced the error rate in replication enough to make possible gene length up to several thousand nucleotides. This barrier is still reflected in the limited gene length of present single stranded RNA viruses, even though the viruses

were in a much later evolutionary development. Further extension of gene length was possible only with the appearance of mechanisms for detecting and correcting errors. Distinction of right from wrong could then be made if the newly formed daughter strand remained associated with its parental template in which case "wrong" could be identified chemically as "unpaired". This was accomplished by the appearance of DNA on the scene equipped with DNA polymerases for fidelity of replication which allowed gene lengths to be extended to millions of nucleotides. At the same time, the high fidelity of replication narrowed the opportunities to provide variability by means of mutation. This obstacle was overcome by the development of recombinative processes through sexual reproduction. Incorporation of these enzymes for high replication fidelity of a stable quasispecies was accompanied by the translation of RNA sequence into the protein because the gene length had now crossed the minimum value for protein synthesis. Quasispecies with its translational product established the genotype and phenotype dichotomy. Stabilization of this system was based on enzymatic replication of genetic information which could be achieved only by translational product of other quasispecies and *viceversa* (Fig. 4). They called it "hypercycle" and postulated three rules for coexistence of quasispecies.

1. Each quasispecies itself must remain stable, i.e., each master sequence must compete successfully with its mutants so that errors do not accumulate.
2. The different master sequences, with different selective values, must tolerate each other because of mutual catalytic couplings.
3. The coupled set must remain stable, regulating the populations of its members and competing as a set with alternative sets.

Likewise, many quasispecies might come to exist for continuity of genetic information. Moreover, new quasispecies could be accommodated or could replace a quasispecies in a hypercycle if the new one developed the affinity for any quasispecies of the hypercycle

during evolution (Fig. 5). Hypercyclic coupling operates today when an RNA virus attacks a cell. Information is supplied as a single plus strand of RNA. It is translated by the machinery of host cell into an enzyme that, with the help of host factors, replicates the RNA producing a minus strand which in turn is replicated to produce a new plus strand (Fig. 6).

Conclusion

To sum up the entire discussion, a few inferences can be drawn regarding the origin of genetic machinery. The abundant energy sources during prebiotic period like lightning, shock waves, ultraviolet radiations or hot volcanic eruptions played a crucial role in conversions of early surface materials into a great variety of organic substances including nucleotides and amino acids. Some of the first nucleotides might have polymerized into nucleic acids in the presence of certain chemical catalysts. Process of selection led to creation of a stable molecule of RNA that attained a definite length for its perpetuation. However, it might have been too small to encode a functional protein. This problem was probably overcome in species rich in G and C nucleotides which caused the RNA to achieve sufficient length to code for a protein. It seems logical that the coding of the protein might have obeyed the stereochemical relationship between nucleotide triplets and amino acids. It led to the establishment of a genetic language which is still omnipresent in all life forms. The appearance of DNA on the biological scene might have been a later development. Probably, it served the purpose of storing a lot of the genetic information because it could attain very large lengths through complementary base pairing as well as protecting the nucleotide sequence (genetic message) from the surrounding environment. Therefore, it helped in the synthesis of large polypeptide chains which could perform a great variety of functions through their more variable amino acid sequences than the short polypeptide chains. Moreover, DNA might have also provided fidelity in replication of genetic message. At the same time, the genetic message of DNA could

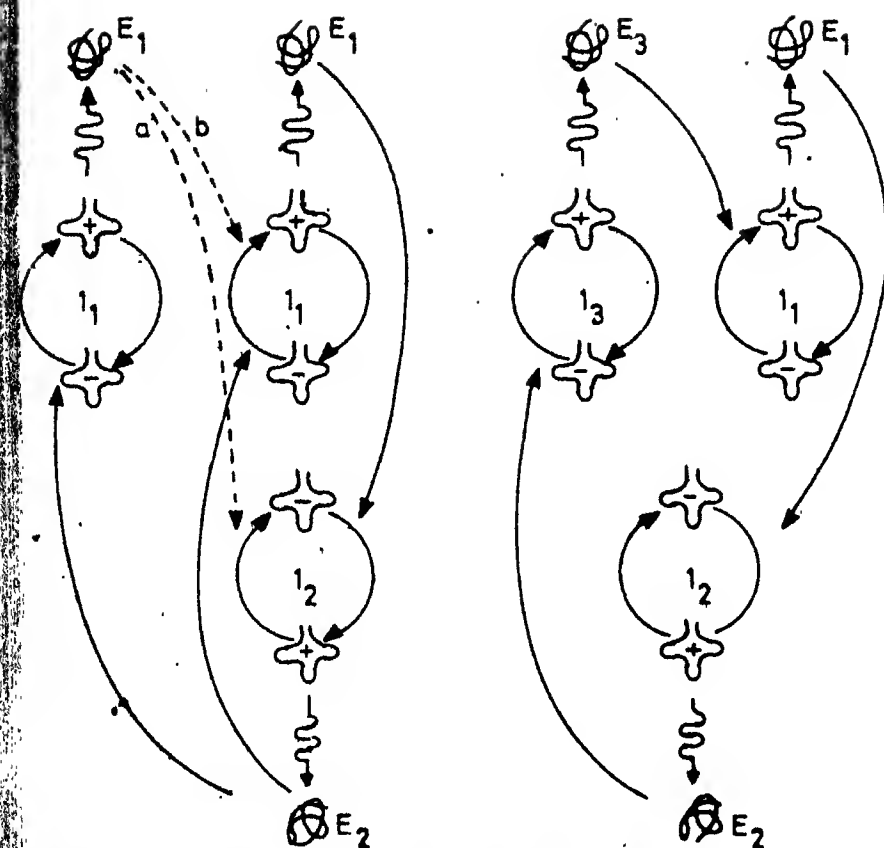
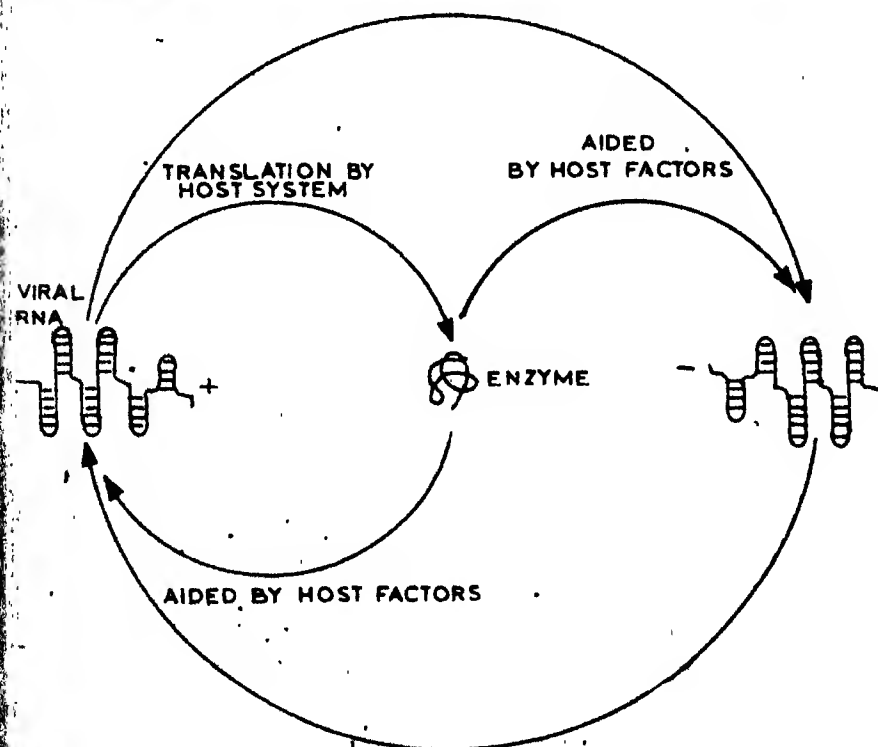


Fig. 5. The mechanism of the hypercycle accommodation in a stable hypercycle coupling; a mutant sequence (I₁) emerges that can compete with I₁ if its translational product (E₁) helps more for I₁ replication than that of the original E₁ (path a). If instead E₁ is more helpful to I₁ than E₂ is (path b), the original hypercycle expands to become three member hypercycle (right)



not be read until the nucleotide sequences were exposed or copied for translation. It was still associated with the RNA molecule. At this stage, various hypercycles may have operated and maintained the continuity of genetic information through the passage of time.

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Fig. 6. Existence of hypercycle coupling in a virus; II introduces a plus strand of RNA that is translated in the presence of host cell's machinery into an enzyme which replicates the RNA, producing a minus strand. The minus strand is replicated further to produce plus strand

LIVING WITH ATOMIC RADIATION

K.S. PARTHASARATHY

What are ionizing radiations, their effects, associated risks and benefits? How do we achieve the objective of radiation protection?

SINCE the discovery of X-rays by W.C. Roentgen in 1895 and radioactivity by Henri Becquerel in 1896, penetrating ionizing radiations have found several applications in medicine, industry, agriculture and research. Many uses of these radiations are unique. A few of them are indispensable. Medically needed radiation procedures save lives. Radioisotope techniques help improve crops, assure quality of industrial products and are irreplaceable in oil prospecting and hydrology. From ensuring proper mix of chocolate and other ingredients in the sweetmeat industry to measuring the flow rate of the Ganges, from helping heart to keep pace to the generation of power for industries, taming of atomic radiation embraces every aspect of human endeavour.

Just as with many other physical and chemical agents, some risk is associated with the use of ionizing radiations. Radiation protection measures maximise benefits and minimise risks. The exposure of man to radiation is inescapable because natural radiation is an inseparable part of the environment. What are ionizing radiations, their effects, associated risks and benefits? How do we achieve the objectives of radiation protection?

Ionizing radiations

All materials, whether animate or inanimate, are made up of an element

or a combination of some of the elements such as oxygen, carbon, hydrogen, nitrogen, calcium, etc. Atom is the smallest particle of an element and is electrically neutral, but when radiations such as X-rays pass through matter, they remove electrons and leave a positively charged ion behind. Such radiations are called ionizing radiations.

Radioisotopes which are atoms with unstable nuclei also emit ionizing radiations either in the form of tiny particles of matter (alpha or beta particles or neutrons) or in the form of packets of energy (gamma rays). Ionizing radiations cannot be seen, smelt or felt. We need special instruments to detect them.

Radiation in the environment

Ionizing radiation is an inseparable part of the living environment. Man is continuously being exposed to natural radiation from outer space, rocks, etc., and man-made sources of radiation (X-rays, artificial radioisotopes). The intensity of radiations from outer space is not reduced significantly by the walls or the roofs of the houses we live in. It is a minimum at the equator near sea level but increases with altitude. Atmosphere itself is a shield against cosmic rays. Air travellers get some extra dose due to cosmic rays. Supersonic aircraft are equipped with radiation monitors. The pilot brings down the aircraft to lower heights when cosmic rays intensity increases due to solar flares. The

increases can be ten fold during these rare events. Cosmic rays also produce radioisotopes such as carbon-14, tritium and beryllium-7 in the atmosphere.

Every cubic metre of ordinary soil in our backyard contains radium, thorium, potassium-40, etc., more than 30 radioisotopes totalling over several Mega becquerel (Bq) of radioactivity (Becquerel is a unit of radioactivity, just as litre is the unit of volume. Mega becquerel is equal to one million Bq. Every becquerel of radioisotope has one atom disintegrating per sec).

Inhabitants of concrete or brick houses receive more radiation dose than those living in wooden houses due to natural radioactivity of the bricks.

Human body contains potassium-40, carbon-14, tritium, radium, thorium, etc. Do you know that several thousand beta particles from man-made radioisotopes are emitted in the human body every second? Gamma rays from a person can reach you when you are near him.

Trace amounts of radioisotopes are present in food, water or air. Milk contains nearly 200 times more radioactivity than drinking water. Radioactivity present in beer is 8 times more than that in drinking water.

Wherever we are, the air we breathe contains measurable amounts of radon and decay products. Radon, an inert radioactive gas, is formed by the decay of radium and thorium in building materials or in the earth's crust. Radon concentration in dwelling increases with decrease in ventilation. In cold countries, the ventilating rates are reduced to cut cost of heating. Radon level increases significantly in energy efficient homes. The concentration of natural radioactivity in air is several hundred times more than that due to man-made sources.

Beach sands of Kerala

The total radiation dose to man varies considerably from place to place. In Kerala the inhabitants of a 55 km strip of beach sands, which contain the world's richest deposits of thorium, receive about 3.8 millisievert per year. The average background radiation dose is assumed to be 1 mSv per year. Sievert is the unit

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Fig.1. Area monitors

biologically effective radiation dose. Millisievert is a thousandth of sievert.

Radiation from man made sources

Medical X-ray procedures contribute the highest among the man-made sources. In advanced countries, the average medical X-ray dose to population is of the same order as the background radiation. Since X-ray facilities in India are too meagre and the population is very large, average medical X-ray dose to population is very small. The contribution to population dose in India from nuclear power generation is negligible. Though the core of a nuclear power reactor contains enormous amounts of radioisotopes, the average population dose is less because of careful engineering design and control measure.

Industrial uses of radiation, colour television sets and watches containing radioluminous compounds contribute small doses to population. The dose from radioactive fallout due to testing of nuclear weapons in the atmosphere is also of small magnitude; thanks to the cessation of atmospheric weapon testing.

Ionizing radiation is a double edged sword. Public is often sensitized by an exaggerated sense of fear, because they mostly associate radiation with the gruesome consequences of nuclear warfare. Actually the effects of radiation on man are more comprehensively understood than

those of any other physical or chemical agent we know of today. The International Commission on Radiological Protection has been updating the data and issuing recommendations since 1928. Its recommendations are accepted more or less uniformly by various national agencies on radiation protection.

Biological effects

Human body is made up of cells. Ionizing radiations passing through the body may kill the cells or leave them undamaged. The functions of the organs are impaired only if too

many cells are damaged or killed. The damage may be repairable at low dose rates. Occasionally the injury to the cells may be such that they may, besides failing to repair the damage completely, reproduce uncontrollably over many years to form cancer. Cancer inducing effect of radiation in human body is not proved conclusively. Radiation exposure to reproductive organs (testes or ovaries) may cause gene mutations in sperms or ova. This may cause genetic effects—effects that manifest in the children and grandchildren of the exposed individual. There is no evidence that irradiation causes genetic effects in man. Still it is prudent to assume that radiation exposure even at low levels brings about some harmful effects, until it is irrefutably proved otherwise.

A dose of several hundred rems given instantaneously to the whole body may be fatal. The same dose or more if given to a small area or to the whole body in several small increments over a period may not be fatal. In radiation treatment of cancer, the cancerous region is exposed to a precisely directed beam of gamma rays to kill the cancer cells with minimum damage to the healthy cells.

Radiation risk compared to other risks

All human activities involve the acceptance of some risk. Smoking,



Fig.2. Radioactive contamination monitor



Fig.3. Radiation Instrument used in radiotherapy

rock climbing, deep sea fishing, driving cars, going for work, etc., are some examples (Table 1). Smoking is admittedly the riskiest of all human activities. Still people continue to smoke 'cancer sticks'. If 200 persons smoke 20 cigarettes per day, one of them may die of lung cancer every year. In the so called safe industries the risk is known to be one in 10,000. The maximum permissible dosage to radiation workers is 50 millisievert annually. But radiation work can be carried out efficiently at average doses much less than 10 per cent of the maximum permissible. At 5 millisievert per year the risk is only one in 20,000. We accept risk in several areas as of no consequence. Though we know that one person above age sixty is dying every 15 min or so, we do not keep a list of substitute speakers in reserve to take care of the eventuality even when all the speakers we invite for a function are aged above 60. The risk in radiation applications is evidently not more than that in other industries.

Benefits of radiations

Currently for more than 50% of cancer patients in India, radiation treatment is the best choice available. Nearly 120 teletherapy machines are used to treat cancer with external gamma rays; small sources of radium

Table 1. Radiation risk compared to risk in other activities

Cause	Chance of death/year
Smoking 20 cigarettes/day	1 in 200
Accidents in deep sea fishing	1 in 400
Natural causes, 40 year old	1 in 500
Accidents on the road	1 in 5000
Accidents in the home	1 in 10,000
Accidents at work	1 in 20,000
Radiation work (0.5 rem/year)	1 in 20,000

226 or cobalt 60 or caesium 137 are introduced into body cavities to treat cancer of mouth or uterus and into tissues to treat cancer of tongue and cheek. Radioisotopes together with modern imaging devices and computers help to diagnose functional disorders of vital organs such as liver, brain, lung, heart and kidney. Medically needed X-ray examinations continue to be the most beneficial life saving procedures. Radiotracers help to decide how much and where fertilizers must be used. Groundnut and rice crops are improved by mutation breeding. Gamma radiographic cameras detect flaws, blow holes and cracks in welds, forgings and fabricated articles. Nuclear logging devices help in oil prospecting. Medical products get sterilized by radiation techniques. Nuclear reactors provide electric power to various industries. In all these uses of radiation benefits far outweigh the risks.

How to achieve radiation protection?

The Divisions of Radiological Protection and Health Physics, Bhabha Atomic Research Centre, Bombay, look after radiation protection in India. Radiation doses to radiation workers are monitored regularly by supplying them with individual radiation measuring devices. The dose records are examined periodically to see that no worker is exposed to doses that exceed the maximum permissible values. The officials from the Division of Radiological Protection inspect radiation installations and offer guidance in improving work practices, etc. The sources are handled by workers who have adequate training and experience. Thousands of packages containing radioactive materials are transported from the Bhabha Atomic Research Centre every year. Rigorous safety regulations exist in packaging, label



Fig.4. Thermoluminescent dosimeter reader



Fig.5. A radiation worker monitors her thyroid for uptake of radiiodine

ling and transporting these materials. All operations involving radiation or radioactivity in the nuclear power programme are carefully planned and executed. Indigenous technology to handle and dispose of radioactive waste materials have been developed. The releases of radioactive materials into the environment are closely controlled. Samples of air, water and food are collected and analysed routinely for their radioisotope content.

Radiation protection in hospitals

Among the man-made sources of ionizing radiation, diagnostic X-ray procedures contribute the highest dose to population. Can this contribution be reduced? Do not

insist on X-ray examinations. Let the doctor decide it. Do not wait inside the X-ray room when other patients are examined. You will be unnecessarily exposed to X-ray if you are inside. X-ray exposure involves a small risk. We need not take it if it is not essential. Keep records of all X-ray examinations. Inform the physicians about all recent X-ray examinations. Repeated X-ray tests may not be needed. Patients to whom therapeutic amounts of radionuclides are applied should be confined to a separate room. Visitors must not remain near the patients.

Radiation and pregnant woman

Pregnant women should be extra careful about the X-ray examination.



Fig.6. An applicator used in radiotherapy of the cancer of cervix.

Patients must inform the doctor whether they are pregnant or think that they might be. The doctor needs this information to decide whether an X-ray examination is essential or not. If the patient informs the doctor that she is pregnant or thinks that she might be, she will not be sent for an X-ray examination unnecessarily. Pregnant women must not visit patients to whom therapeutic amounts of radioisotopes have been administered. The patient need not panic if any X-ray examination is undertaken when she is pregnant. In medically needed radiation procedures benefits far outweigh the risks.

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periodical
SCIENCE REPORTER
Form IV
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- | | |
|---|--|
| 1 Place of publication | Publications & Information Directorate
(C.S.I.R.), Hillside Road
New Delhi-110012. |
| 2 Periodicity of its publication | Monthly |
| 3 Printer's name | S.P. Ambasta |
| Nationality | Indian |
| (address) | Pub. & Inf. Dte., (C.S.I.R.)
Hillside Road, New Delhi-110012 |
| 4 Publisher's name | S P Ambasta |
| Nationality | Indian |
| (address) | Pub. & Inf. Dte., (C.S.I.R.)
Hillside Road, New Delhi-110012 |
| 5 Editor's name | S P Ambasta |
| Nationality | Indian |
| (address) | Pub. & Inf. Dte., (C.S.I.R.)
Hillside Road, New Delhi-110012 |
| 6 Names and addresses of individuals
who own the newspaper and partners or
shareholders holding more than one per
cent of the total capital. | |

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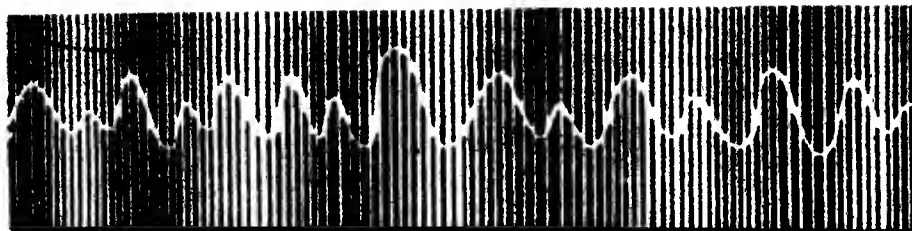
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SCIENCE SPECTRUM

Lowell's prediction of Pluto challenged

BEFORE the discovery of Pluto on January 21, 1930 by Clyde Tombaugh at the Lowell Observatory, Arizona, U.S.A., several astronomers, about half a dozen in number, had made predictions about its presence in the sky. But the credit for the prediction is mainly given to the famous mapper of the Martian canals, Percival Lowell of the Flagstaff Observatory. If some historian of science is a little more considerate, W.H. Pickering of Mount Wilson Observatory would also be included in the credit list. But everybody has forgotten or ignored the prediction of Pluto made by an Indian astronomer V.B. Ketakar despite the fact that his prediction was the earliest of all and his findings were reported in the May 1911 issue of the *Bulletin of Astronomical Society of France* (J. of Societe Astronomique, France). Moreover, his prediction of the position of Pluto was not only more accurate than those of Lowell and Pickering but was also based on methods different from those adopted by all western astronomers. So claim three physicists J.G. Chhabra, S.N. Sharma and Manju Khanna of Punjabi University in the latest issue of the *Indian Journal of History of Science* Vol. 19 (1). Besides, Ketakar had also predicted the presence of what is today known as the "X-planet", the as yet undiscovered tenth planet in the solar system. He therefore deserves the recognition due to him in the history of astronomy.

Lowell and Pickering had made predictions of Pluto on the basis of gravitational perturbations of the known planets, Uranus and Neptune.

In other words, on the basis of gravitational forces acting on a known planet, its path was determined and then matched with its observed one. The difference between the two, if any, called "gravitational perturbation", was naturally attributed to unknown gravitational forces due to undiscovered planets or bodies in the solar system. In 1915, Lowell predicted the presence of one planet but with two sets of orbital parameters. On the other hand, Pickering predicted a series of planets beyond the asteroid belt, seven in number, during 1909-1932. Ketakar however predicted the presence of two planets, called "Brahma" and "Vishnu" after two Hindu deities, taking the Jovian system as a miniature solar system. Modifying the Laplace's laws for the Jovian system, which were then already confirmed by Delambre, he predicted the position of Pluto on some important dates from astronomical point of view. The extracts of his findings duly appeared in the aforementioned French journal.

Only a year later, Ketakar further confirmed his prediction of Pluto on basis of the aphelions of comets. The paths of periodic comets are influenced by the gravitational forces of planets. He found that the aphelions of a few comets fall beyond Neptune indicating the presence of an unknown planet. In fact, in his letter dated April 14, 1912, addressed to M.C. Flammarion, of the Astronomical Society of France, he reiterated his faith in the existence of Pluto around 39 A.U. -40 A.U.

Unfortunately, more than a year before Pluto was discovered, Ketakar suffered a paralytic stroke. He could not even speak and could not stake his claim for the prediction of Pluto. He died soon afterwards, forgotten and ignored until his papers and correspondence were discovered by S.N. Sharma. In the meanwhile, Pickering gave up his claim for the prediction of Pluto in favour of Lowell because the latter had kept some money for a deliberate search for the planet.

In the aforementioned paper, the three physicists have also made a comparative study of the findings of Lowell, Pickering and Ketakar for a specific date taking their predicted orbital parameters that are closest to those of Pluto. They found that while Lowell's and Pickering's predicted longitudes of Pluto differed from the observed one by 5.9 and 5.6 respectively, Ketakar's differ only by 0.6! It seems as if Tombaugh's discovery of Pluto on the basis of predictions by Lowell and Pickering was sheer coincidence. Moreover, in 1930, Ernest W. Brown, a celestial mechanics scholar of Yale University, U.S.A., claimed that predictions of unknown planets beyond Uranus and Neptune on the basis of their gravitational perturbations cannot be made because they are very small and experimental errors are very large. In fact, when in 1926 Ketakar met another Indian astronomer H.P. Bhatta he told him that he had adopted new methods for prediction of trans-Neptunian planets because gravitational perturbations of Uranus and Neptune are very small. From the accuracy of prediction of Pluto by Ketakar it has now been proved beyond doubt that his was a reliable method, although it does not give all the orbital parameters of a planet. It has now also come to light that some of the orbital parameters of Ketakar's predicted "Vishnu", the tenth planet, come close to those of the X-planet as predicted in recent times by Joseph J. Brady of Caltech. Brady had used periods of Halley's comet from old European and Chinese records for computation. Although enthusiasm for the X-planet has waned in recent times due to futile searches and also as the solar system is found to be

difficult to exist if all Brady's findings are correct, there is a need to take a

fresh look into Ketakar's work on the elusive planet.

Dilip M. Salvi

Arrival of a new phylum —Loricifera

DISCOVERY of a new phylum is a rare happening in the scientific world. During this century, it is only for the third time that a new phylum—Loricifera—has been discovered and added to the animal kingdom making the total number of phylum thirtyfive. The new phylum comprises of the marine animals inhabiting the sea. The credit for the discovery goes to Reinhardt Kristensen of the University of Copenhagen, Denmark, who found the specimens at a depth of 25 m-30 m, clinged to shell gravels. However, it was Robbert Higgins, a researcher at the National Museum of Natural History, Washington, D.C., who for the first time predicted in 1961, the presence of the newly described phylum, while he was only a graduate student. Higgins later found one specimen in 1974 also but unfortunately failed to recognise it as a new and undescribed organism.

The new phylum would have been discovered eight years earlier; when Kristensen first found a single specimen in 1975 in a sample of coarse subtidal sand off Denmark. But a minor mistake in preparation of the slide for microscopic study destroyed the specimen and caused delay. He again encountered these marine creatures in 1980 in a sample of sand from the coral sea of the south pacific. On examination they revealed to be the larval stages of the organism. Then came the eventful year of 1982 when Kristensen found all stages of life cycle of the animal by an accident at a time. Kristensen was on a trip to the Marine Biological Station at Roscoff in France. On the last day of stay, he found a huge sample (more than 100 kg) of clean shelly gravels from a sea depth of 25-30 meters. Due to shortage of time, he hurriedly processed the sample by an unconventional method in which he used fresh water to rinse out the interstitial animals. In standard method of extraction, mercuric chloride is used. Interest-

ingly, unconventional method proved specially effective and he got an entire set of stages of life cycle. He studied them thoroughly and quickly named it as *Nanaloricus mysticus*—the first member of the phylum loricifera.

Characteristic features

These tiny creatures, along with some other similar organisms of relatively unexplored biological territory, are collectively known as "meiofauna" due to their diminutive size. The members of the new phylum inhabit marine sand and grounds at depth of tens to hundreds of meter below the sea surface. The tiny adult specimens measure less than 0.5 mm while the larvae are still minute measuring only 0.25 mm. The organism possesses a combination of characters which are similar to those found in about five other but related phyla. The adult has a head with a haystack like mass of appendages. The most characteristic feature of Loricifera is its feeding apparatus. The mouth is in the form of a flexible tube which

together with head can be retracted into the organism's main body. When the mouth cone and head are withdrawn are into the plated abdomen, the appendages fold over like the ribs of an umbrella blown in opposite direction. The one end of the larvae resembles a telescope while at the other end a propeller-like structure is present. The telescope-like portion consists of two parts—the mouth and head. When the larvae are disturbed, they withdraw their mouths into the spiny heads which in turn can be withdrawn into the neck. The propeller-like portion consists of a pair of blade-like appendages known as toes. These appendages are attached to the main body by a ball and socket joint. This facilitates its rotation in all directions. A further set of three pairs of appendages is present in the centre of the animal's body. The last set of these three sets together with the ends of the toes forms the locomotory organs of the animal, used to crawl over sand grains.

Most probably the adults are sedentary and ectoparasite, while the larvae are free living and have been found swimming around. When organisms move slowly the toes are used as paddles; however, their action at fast speed could not be worked out by Kristensen. Before their metamorphosis into adults, the larvae moult several times. These diminutive larvae are named after Robbert Higgins, who first found them and also collabor-

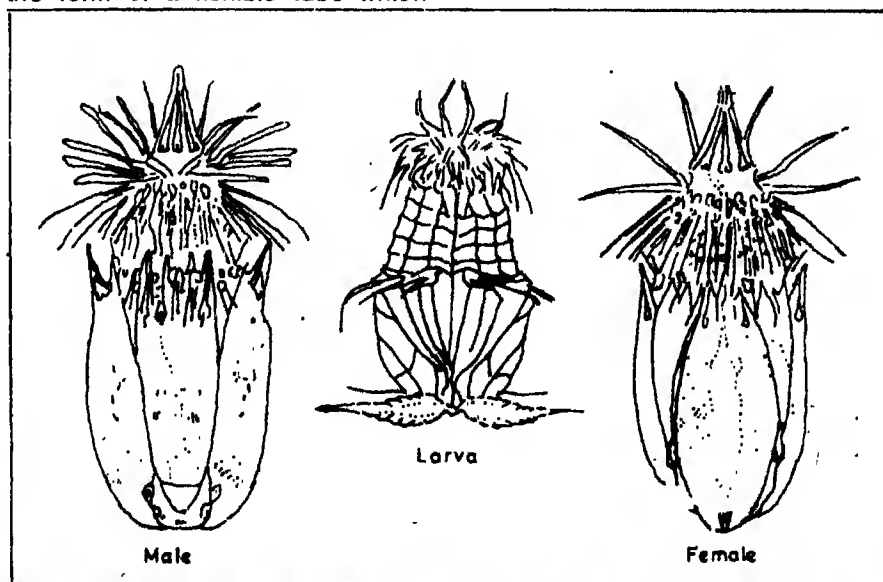


Fig.1: Adult (both male and female) and larva of *Nanaloricus mysticus*. Note the haystack like appendages

Conducting plastics

WHEN atoms are brought together to form a crystal, the interatomic interactions spread out the degenerate atomic energy levels into bands. In many cases, the interaction is sufficient to broaden the bands so that they may merge into one another. When the energy gap between the highest filled and the lowest empty energy band is large, the material is an insulator. As the gap decreases, thermal excitation of electrons to the empty (conduction) band from the filled (valence) band is possible and the material is an intrinsic semiconductor. When the gap between the bands closes, the material becomes a metal.

Ever since John Hyatt, an American inventor, created the first synthetic polymer, plastics have been thought of as electrical insulators. Recent discoveries of molecular crystals and polymers that exhibit metallic levels of conductivity and even superconductivity have drastically altered the situation. Such materials have been termed "molecular metals". "They have provided new insights into the solid state properties of organic systems and offer prospects of many technological applications in the future", said David Bloor, reader in polymer physics at Queen Mary College, London.

In a rather uncanny experiment to turn a tiny amount of acetylene into an organic polymer (CH)_x, polyacetylene in 1970, a student of chemist Hideki Shirakawa at the Tokyo Institute of Technology, instead of obtaining a black powder, got a silvery film that looked like a metal. Five years later, Shirakawa joined physicist Alan Heeger and Alan MacDiarmid, a University of Pennsylvania chemist, in their Philadelphia Laboratory to investigate the properties of the puzzling substance. This collaboration soon led to another surprising discovery. Polymers can be doped with various substances to change their

properties. When a researcher intentionally contaminated or doped the new plastic with a small amount of iodine, properties of the polymer were altered radically. This doping had increased the plastic ability to conduct electricity as much as a trillion fold. For the first time, scientists had created a plastic that was as good an electrical conductor as a metal.

Technological promise of plastics that are also electrical conductors may readily lend themselves to a host of novel products of electrical and electronic components made of plastic. One application in particular has since drawn the attention of a number of manufacturers: a super light weight car battery that might at long last make quiet, non-polluting electric cars both practical and economical.

When electrochemically treated with anions such as (I₃⁻) (ClO₄⁻) or (AsF₆⁻) using the tetrabutyl ammonium salt dissolved in CH₂Cl₂, polyacetylene can be transformed from an insulator into a p-type semiconductor, i.e., a material that conducts electricity by means of electron holes. This occurs by partial oxidation of the (CH)_x with ions being taken up to preserve electrical neutrality giving a material of general composition (CH_x⁺ A_y⁻)_x where A is an anion. D. MacInnes and his colleagues at the University of Pennsylvania found that (CH)_x can be reversibly doped either p-type or n-type (i.e., conducting electricity by means of 'spare' electrons) and they envisage that materials in these states can be combined to conduct rechargeable electric cells.

The new results show that when a strip of Li and a strip of (CH)_x are placed in a solution of LiClO₄ in tetrahydrofuran (THF) and connected through an ammeter, spontaneous n-type doping to CH_x⁻ Li_y⁺ occurs and an electric current is detected by the ammeter—the arrangement acts as a battery until doping is complete. The

battery can be recharged if an electric potential is put across the two electrodes. p-Type doping of (CH)_x can be achieved if the (CH)_x electrode is attached to the +ve terminal of a dc source, the other terminal being attached to a Pt, Li, Al or even (CH)_x electrode. This means that two polymer electrodes if connected to a dc source and immersed in LiClO₄ electrolyte will simultaneously be oxidised and reduced. Upon discharge through a circuit the oxidation states equalise (the films become undoped) and a current will be produced.

The team at Pennsylvania has tested a number of configurations of different electrode and electrolyte materials. The (CH)_x(LiClO₄) Li or Al battery with propylene carbonate solvent has been the most extensively investigated. Even with only 3 mg of doped film, the discharge currents and voltages are remarkably high for several minutes of short circuit discharge. Higher degrees of oxidation and reduction that are obtainable will result in higher voltages, currents, energy and power densities in a battery configuration.

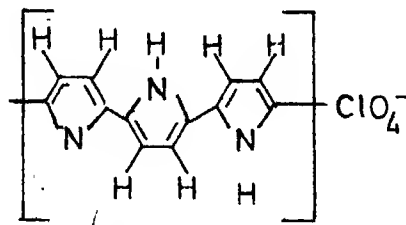
Taking advantage of this conductivity, industrial researchers have already produced scaled-down experimental plastic batteries that weigh a third less than comparable conventional batteries. So far these plastic marvels have been confined to the laboratory. But Allied Corporation, Morristown, New Jersey, which bought licensing rights from the University of Pennsylvania in 1981 to manufacture plastic batteries, hopes to bring out a commercial version to the market within the next several years. Besides, those plastic cells can be charged and discharged more than a thousand times and much faster than conventional lead acid batteries. In an electric car, such a rapid delivery of power would vastly improve acceleration and hill climbing ability, both solely deficient in today's electric vehicles. Unlike the process in conventional batteries, the electrolyte, rather than the electrodes themselves, contributes the ions that shuttle between the two electrodes. As the ions cling to the electrodes, they dope the polymer and change its potential. Because the ions are drawn from electrolytes, not from the poly-

mer, the electrodes have virtually no wear and tear and remain intact through countless charging and discharging cycles. Chemist Fred Wudl of the University of California at Santa Barbara said, "Theoretically you should be able to go on using the battery for ever."

Although the Pennsylvania group has shown that $(CH)_x$ could be used as a battery material—its oxidation-reduction is reversible—there are considerable problems with the polymer as a workable material. It is unstable in air, gradually loses its conductivity and becomes brittle. It is difficult to characterise and to process. Hence many workers are looking for other organic polymers with metallic properties, in particular those possessing aromatic and heterocyclic units.

According to Brian Street, a senior researcher at IBM research centre in San Jose, California, conducting derivatives of polypyrrole look promising. IBM first became interested in polypyrroles in the late 1970's. Since then Street and his colleagues have prepared films of polypyrroles with p-type conductivities of upto $100 \Omega^{-1} \text{ cm}^{-1}$, by the electrolytic oxidation of pyrrole in acetonitrile solution using either tetraethylammonium tetrafluoroborate or silver perchlorate as an electrolyte (under drybox conditions). A film of β -pyrrole tetrafluoroborate (perchlorate) is formed on the platinum anode, it shines, is blue black, nonfibrous and flexible. Most exciting of all, it is stable in air and can be heated to 250°C with little effect on the conducting properties. The idealised structure of polypyrrole perchlorate is as shown in Fig 1.

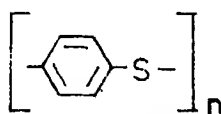
So, are polypyrroles a step in the right direction? For a conducting plastic to be useful, it must have good mechanical properties, e.g., flexibility, plasticity, elasticity, and tensile strength. It must also be stable, light, processible and cheap. Studies indicate that polypyrrole satisfies most of these requirements but is difficult to characterise and process, and is expensive. Although conducting polypyrrole was first characterised as a metal but workers now regard it as a degenerate semiconductor like amorphous silicon. Further studies show that it cannot be n-doped (reduced)



and its use in, say, diodes may be a long way off.

However, oxidised polypyrrole films prepared electrochemically are very stable under electrolytic conditions and have good adhesion, making them attractive organic electrode materials. Since polypyrrole itself is non-conducting, its electrical properties can be switched on and off electrochemically, by reversing oxidation.

The main problem associated with these materials such as doped polyacetylene and polypyrrole is a lack of commercial application at present. Another obstacle is that the polymers are not cheap. To overcome these problems, scientists have recently reported a new compound, poly(p-phenylene sulphide) (PPS) doped with AsF_5 and dissolved in liquid AsF_5 . PPS is readily available commercially and therefore inexpensive. Secondly, its structure offers some interesting possibilities (Fig.2).



The sulphur atom between the two benzene rings acts as a hinge, introducing a degree of flexibility. PPS is indeed a melt processible polymer. It is also somewhat different from other polymer precursors in not having a continuous system of overlapping carbon orbitals.

When PPS was exposed to AsF_5 in the gas phase, its conductivity increased by 16 orders of magnitudes to $1 \Omega^{-1} \text{ cm}^{-1}$, but unfortunately the doped material lost the attractive mechanical properties of the parent plastic. However, when doping was carried out in the presence of AsF_5 vapour, which acts as a plasticiser, the resulting film was much more flexible and homogenous. The researchers then tried doping PPS in

liquid AsF_5 and discovered that they had a conducting polymer solution. Moreover, the polymer films cast from the solution by evaporation had improved flexibility and strength and very much higher conductivity ($200 \Omega^{-1} \text{ cm}^{-1}$). Dilute solution of PPS are infinitely stable in dry air.

The deep blue solution itself is interesting because it offers the opportunity to study electronic conduction in polymers spectroscopically with higher resolution. ESR studies indicate similarities to metal-ammonia solutions. The conduction is basically electronic. The ionic component of conduction increases with dilution. Not only can flexible films be cast from solution but there is also the possibility of producing fibres (e.g., for wire). The Allied Workers are very pleased with their new technique and are looking at oxygen substituted polymers and also other dopants besides toxic AsF_5 .

Indeed as chemists have learnt to tailor-make the plastic with specific chemical and physical properties, they are now in a position to produce a range of new electrically conducting polymers that could replace costlier metals in everything from motors and wires to magnets and generators.

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Dangers from non-ionising radiations

THE hazards of ionising radiations are well documented, safety standards are laid down in codes of practice, and adequate instrumentation is readily available. Increasingly, however, working scientists are exposed to hazards from non-ionising radiations where the position is not so clear. This short article is an attempt to provide guidance in these circumstances. Although prepared for the use of physicists in hospitals, the guidelines are relevant to physicists working in other environments. In all cases, safe working depends on: (i) the appointment of a responsible person who must be properly trained;

SCIENCE SPECTRUM

(ii) the use of operating instructions or local rules; (iii) the identification of persons at risk and of areas of possible high exposure; (iv) medical surveillance; and (v) the preparation of accident plans. Now consider different non-ionising radiations.

Microwaves

The correct basis for safety standards should be a measurement of absorbed energy, but this is not possible at present; instead, exposure values are used. Dosimetry presents problems. Although it is possible to measure power densities in a free field condition, the introduction of test objects, patients and operators into the field causes considerable distortion and it becomes extremely difficult to relate the free field measurement to the absorbed power density. Protection policy has to be based on the mapping of areas where power densities exceed a particular level and then appropriate warning signs and local rules must be used.

In Western countries, exposure limits are based on irreversible thermal injuries, whereas the limits in many East European countries are based on reversible non-thermal effects and are a thousand times lower. The Medical Research Council standard for continuous exposure allows up to 100 W m^{-2} , and this is comparable with the average heat dissipation from the body of 50 W m^{-2} . For discontinuous or intermittent exposure the limit is 10 W m^{-2} during any 0.1 hour period. The critical organ is the lens of the eye due to its poor cooling mechanism, and in certain cases eye protection with mesh goggles should be considered. An additional standard that can be applied is the equipment emission standard of the U.S. Department of Health, Education and Welfare (DHEW), which requires the leakage to be less than 50 W m^{-2} at 5 cm during use. In normal use, average exposures to persons working nearby are not likely to exceed 100 m W m^{-2} .

Lasers

A characteristic of all laser beams is the high power density at long distances. The critical organ is normally

taken to be the eye. The eye is relatively transparent to wavelengths between 400 nm and 1400 nm and the focussing action can increase the power density on the retina by a factor of 10^5 . The risk will depend upon such parameters as power density, exposure time, wavelength and pupil diameter. For wavelengths in the ultraviolet and far infrared that cannot penetrate the lens, it will be the cornea that is most at risk, along with other areas of exposed skin. Control of laser hazards should be based on engineering design, warning notices, and attention to a strict operating procedure rather than on protective clothing and goggles. Examples of the types of instruments and their related hazards include low power helium-neon lasers, which if less than 1 mW, can be used with only minimal safety precautions; 2 W argon lasers operating in the blue-green waveband should be treated with extreme caution; and 40 W CO_2 lasers operating in the far infrared can cause thermal injury to the skin and cornea.

Incoherent ultraviolet

Ultraviolet radiation is classified into three ranges. UVA (400 nm-315 nm) is called the blacklight region, UVB (314 nm-280 nm) is called the erythral region, and UVC (280 nm-100 nm) is called the germicidal region. A variety of both early and late effects on the skin can be identified, namely, erythema, aging and cancer, and in the eye keratoconjunctivitis and cataract. Threshold levels are very dependent on the susceptibility of the individual, skin colour, previous exposure, age and irradiated site, the most hazardous wavelength being 270 nm. Radiation below 250 nm is also capable of producing ozone and other toxic decomposition products. Besides, there is the additional hazard due to the breaking of lamp envelopes on high pressure filling.

Threshold limit values for occupational exposure published by the American Conference of Government Industrial Hygienists have been adopted by many countries. These specify a total irradiance in the region 400 nm-315 nm incident on the skin or eye not exceeding 100 W m^{-2} for peri-

ods greater than 10^3 s, and a total radiant exposure not exceeding 10^4 J m^{-2} over shorter periods. Within the range 315 nm-200 nm, the maximum permissible exposure is 30 J m^{-2} in an eight hour period. For broad band sources, it is necessary to derive the effective irradiance relative to the monochromatic wavelength of 270 nm either by using an instrument with a weighted response or by the use of scanning spectral radiometer.

Sound

Noise exposure is known to result in increasing deafness which is added to age-induced hearing loss. In the range 90 dB(A)-100 dB(A), the damage will be proportional to the total weighted sound energy falling on the ear, and it can take years to develop, whereas above 130 dB(A) the damage is immediately apparent. The relevant code of practice states that continuous exposure of the unprotected ear during an eight hour working day should not exceed 90 dB(A), noncontinuous exposures should not exceed 135 dB(A), and impulses should not exceed 150 dB(A).

Ultrasound

Ultrasound is used at power levels of a few tens of W m^{-2} for medical diagnosis, at a few 10^4 W m^{-2} for physiotherapy and up to 10^6 W m^{-2} for surgical destruction. Biological effects are known to occur at the higher intensity levels. In the low megahertz frequency range, there have been (as of this date) no demonstrated significant biological effects in mammalian tissues exposed to intensities below 100 nW cm^{-2} (10^3 W m^{-2}). Furthermore, for ultrasonic exposure times less than 500s and greater than one second, such effects have not been demonstrated even at higher intensities, when the product of intensity and exposure time is less than 50 J cm^{-2} ($5 \times 10^6 \text{ J m}^{-2}$).

A World Health Organisation working group stated in October 1976 that there were insufficient data available on minimum exposure levels to be able to make recommendations, but it believed that direct exposure was of more concern than indirect exposure. It felt that diagnostic examinations should be carried out with as low an

exposure level as could be achieved commensurate with obtaining good quality diagnostic information.

Since ultrasound is effectively absorbed in air at high frequencies, ears only need to be protected when high levels of subharmonic distortion in the audible range are present. Ultrasonic cleaners are potentially

hazardous. Hands should therefore not be put in them during operation.

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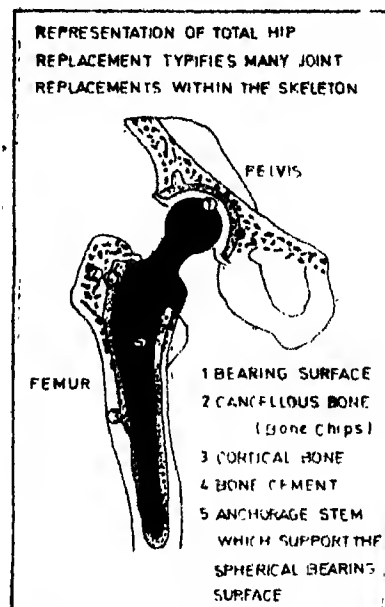
Ceramics—a new material for biomedical applications

CERAMICS are a new group of materials which are swiftly entering the field of biomedical applications. They have been successfully used in quite a few dental and orthopaedic implants and have proved better than conventional implant materials like stainless steel and dense polyethylene in many cases. Materials for such bioapplications must submit to a host of stringent requirements since components once implanted are no longer available for testing or inspection. Broadly speaking, they should be absolutely compatible with the host tissue, should be corrosion resistant and in the case of bearing surfaces (e.g., the ball-and-socket joint) should be wear resistant. Moreover, they should be strong enough to withstand the load implied on them and should be sufficiently fatigue resistant to provide a long service life. The excellent properties displayed by some ceramic materials in these respects have been the reasons for their gaining fast acceptance as a bio-material. Of course, the medical community is still sceptical about inherently brittle nature of ceramic, but a lot of research is being conducted nowadays to overcome this problem.

Alumina (Al_2O_3), is classified as being more bio-inert (no reaction with living tissue) than metals and polymers and is used in both porous and dense forms for orthopaedic and dental applications. Porosity in implants has been found to encourage bone regrowth into the implant, thus obviating the necessity for bone

cement—a material joining the implant to the bone. Dense alumina has been used by a U.S. firm to make dental implants which have successfully replaced human teeth. It has also been used for the past ten years in hip replacements for manufacture of the spherical head of the hip prosthesis. This head rotates and slides against a UHMWPE (ultra high molecular weight polyethylene) counterface. The combination of alumina/UHMWPE exhibits extremely low wear—this criterion is essential since wear debris can induce inflammatory reactions. Natural and healthy joints are almost wear free, being lined with cartilage and lubricated with synovial fluid.

Apatite (calcium phosphate) is also becoming increasingly popular because of its similarity to natural bone mineral. This gives rise to excellent biocompatibility. Apatite implants have been found to have a very strong and direct chemical bonding to the bone. It is used in two common forms—TCP (tri calcium phosphate) and HA (hydroxyapatite). Porous TCP has been used as bone graft substitutes while dense HA has been successfully used for replacing bone in the jaw. This is far superior to the conventional procedure involving removal of a rib or hip bone for reinserting into the jaw. Granular HA is simply injected under the skin of the jaw. Permanent dentures can be fitted after a waiting period of only four to six weeks as against four to six months in the conventional procedure.



Calcium phosphate is also being studied in glass form with silica (SiO_2) forming a network in the material. Termed bioglass, it contains sodium and fluorine. Its advantage is that it is 'surface active', i.e., its surface provides chemical bonding sites for soft tissues and cell membranes. But due to its brittleness, applications of bioglass have been restricted to coatings on metal implants. However, recent research on reinforcement of bioglass with stainless steel fibres has shown marked improvement in physical properties making bioglass a potential implant material itself.

Recently a form of tetrasilicic mica glass ceramic has been developed by scientists at Corning, U.S.A. which is used for making dental crowns and bridges. Its colour and feel match with those of teeth. Code named 'Wisdom' it can be simply cast into the form of the tooth portion it replaces and can be directly cemented onto the remaining tooth structure.

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Plasma albumin

PLASMA albumin is the most plentiful protein in mammalian plasma. It is synthesized by liver cells and makes its way into plasma via endoplasmic reticulum and golgi complex. The normal value of albumin in human plasma depends upon the food intake. It lies in the range 4gm-6gm/100 ml blood. Level of plasma albumin represents the net result of its catabolism, synthesis and mobilization. Therefore it has been used as a diagnostic parameter in clinical biochemistry. Besides blood, the protein occurs in other tissues also such as muscles and skin. About 40% of the total protein occurs in blood. Due to its easy availability it has been used as a model protein and a wealth of information on it is available now.

A monomeric protein of molecular weight 69,000 it has been sequenced having 582 amino acid residues. Based on sequence data, analysis of peptide fragments and hydrodynamic measurements, a partial domain model for globular structure of protein has been proposed by J.R. Brown in 1976. According to this model, albumin comprises three major domains which in turn are composed of subdomains. The subdomains consist of cylindrical segments formed by apposition of α -helical regions. These helical regions form elongated pockets for several ligands.

Albumin is the general physiological carrier of many exogenous and endogenous substances. Among endogenous ligands, fatty acids, lysolecithin, tryptophan, hemin and bilirubin are more important. It also carries many hydrophobic drugs and dyes which are exogenous in nature. The remarkably large variety of bound ligands contributes to the physiological importance of albumin. In many cases, binding of a compound to albumin has a significant influence on its distribution in the organism and for some highly bound drugs, changes in the binding has consequences for the pharmacological response of the drug.

As a carrier it binds bilirubin, the breakdown product of heme, to liver for conjugation with glucuronic acid and subsequent excretion. It has been observed clinically and in experimental systems that when bilirubin to albumin ratio exceeds one, bilirubin binds to cell membranes. This is a common occurrence in new born infants, particularly if premature and the deposition of bilirubin in the basal ganglia of brain leads to a clinical syndrome known as kernicterus, involving neurological impairment.

The concentration of this protein in the plasma has long been used as an indicator of health and disease. Over 25,000 kilograms of human albumins are administered intravenously in the United States per year mainly to improve the performance of the circulating system. Albumin may be infused during exchange transfusion to prevent kernicterus in new born infants, improvement in bilirubin removal can usually be demonstrated and the remaining bilirubin rendered less toxic. There is no known pathologic condition associated with elevated plasma albumin concentration.

Hyper-albuminemia is so rare as to be regarded as the result of dehydration or an overshoot of the regulatory mechanism. Decreased albumin concentration is encountered in numerous conditions, including malignancies, liver diseases, stress, trauma, malnutrition and nephrotic syndrome.

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The venom in a bee sting

IT is an irony that while the honey-bee produces the mellifluous honey, it also carries a poisonous chemical which it injects into its victims. In general the bee sting, though very painful, is not known to be fatal except in rare cases where the individual is allergic to the bee venom. Instances are several where the victims have survived even a simultaneous mass attack of venomous bees.

When a bee stings, it injects about one microlitre of a 30% aqueous protein solution just below the skin causing a painful swelling. This venom is produced by small-venom glands in worker bees, slowly and gradually over a period of three weeks after their emergence from the hive when they actually start foraging. Queen bees are however equipped with large Y-shaped venom glands 4 cm to 5 cm long and with a diameter of 0.2 mm to 0.3 mm, capable of producing venom

at full capacity at the time of their emergence, possibly to enable them to destroy any rival queen in the same hive.

Two different chemicals seem to be responsible for the normal inflammatory and allergic reaction caused by bee venom. It has five major constituents—two enzymes (phospholipase A₂ and hyaluronidase) and three basic peptides (melittin, apamine MCD peptide), the last is named after its action, mast cell degranulating peptide. Mast cells produce histamine which they store in granules. The MCD peptide provokes the release of histamine from the mast cells which in turn causes inflammation. Melittin also liberates histamine and although is not as potent as MCD it is present in much larger quantities. Melittin is the main constituent of the bee venom making up about half its dry weight. Moreover it has one spe-

cial property which makes it very interesting to biochemist. It breaks up cells, including the red blood cells as also simple vesicles such as liposomes. This lytic ability of melittin is the culmination of a series of complex steps. First, the peptide forms a complex with the cell phospholipid membrane and embeds itself in the lipid layer. This disrupts the normal leak-proof organization of the membrane and either directly makes it leaky or enables the phospholipase to get a grip on the membrane and form lyso phospholipids which puncture it. Melittin not only causes histamine release, but also directly damages cells.

Biochemists were puzzled by the fact that while melittin destroys other cells, the cells manufacturing melittin are left intact. How does the bee manage to prevent melittin from destroying the very cells which manufacture it? Clearly the peptide cannot be synthesised in its active form or it would rupture the cell during secretion. This meant that a less active precursor must be made first, a process known to occur in the manufacture of some peptide hormones.

In a series of steps devised as a part of the research experiment to analyse the venom, it was discovered that there was a new peptide, which was the precursor substance now called promelittin, i.e., by using radioactive amino acids, radioactive melittin was separated from other constituents of the venom gland and further extractions into butanol at alkaline pH resulted in the isolation of the new peptide precursor promelittin. Further confirmation of the precursor substance was found in the presence of the promelittin in the newly emerged worker bees and its absence in the mature ejected venom.

The new peptide contained all the 26 amino acids of melittin in addition to a propeptide at the amino-end of the chain.

Further studies with messenger RNA of the melittin gene have revealed that the messenger code gives us another polypeptide which differs from the promelittin both at the carboxyl and at the amino ends, called pre promelittin whose structure consists of pre-region of 21

residues followed by the pro part composed of 22 amino acids, which in turn is followed by the melittin sequence proper with an extra glycine residue at the carboxyl end.

The function of the prosequence is to inactivate the venom. But what is the function of presequence? It is likely that the pre promelittin is the primary product of translation and that its 70 amino acids represent the entire coding capacity of the melittin messenger RNA.

It may be of interest to note here that precursors with a presequence of about 20 apolar amino acids have been found for a variety of polypeptides, destined for secretion from the cell, such as antibody light chains, pretrypsinogen, preproalbumin, preproinsulin, preproparathyroid hormones. This supports the signal theory that this apolar propeptide is the signal to the cell, that this is a secretory protein to be exported.

While the removal of the pre-

quence appears to be an old well-established reaction, the second step of generation of melittin from its precursors is a unique reaction without any parallel in other animal cells. This is the step that converts the terminal glutamyl-glycine sequence into a terminal amide. Finally the third reaction of converting promelittin to melittin is a definite specialization of bees. With the evolution of the prosequence the bee must have evolved a highly specific processing mechanism guaranteeing conversion at precisely the site where the product can no longer harm the synthesizing cells of the gland, necessitating perhaps an extra cellular enzymes to be secreted along with the promelittin. Further studies of bee venom are expected to lead to new insights into the bio-synthetic pathways of the peptide hormones, thus opening a new and fascinating chapter.

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Ricin : a toxic plant protein from castor oil plant

SOME of the most toxic substances from plant tissues include abrin (from *Abrus precatorius* seeds), modeccin (from *Modecca digitata* roots), viscumin (from mistletoe *Viscum album* leaves) and ricin (from the seeds of the castor oil plant *Ricinus communis*). They have been used in folk medicine against a wide variety of diseases and also for various non-medical purposes. *Abrus precatorius* and *Ricinus communis* plants are described in the Sanskrit work on medicine *Susruta Ayurveda* of sixth century (B.C). These toxins are proteinous in nature and are similar in their structure and mechanism of action and are capable of irreversibly shutting down the synthesis of proteins in eukaryotic cells. They all are heterodimers and bind to galactose in cell membrane.

Structure

Ricin together with the closely related divalent lectin, agglutinin, is

present in the endosperm cells of *Ricinus communis* seeds. In these cells they are confined to the matrix fraction of the protein bodies. These proteins can be easily purified from cell extracts using affinity chromatography by virtue of their ability to bind galactose. Intact ricin has a molecular weight of 62,000 and consists of two polypeptide chains joined by a single disulphide bond. One of these chains, designated the A chain, has a molecular weight of 30,600 and contains one N-linked oligosaccharide, while the B chain (molecular weight 31,400) contains two oligosaccharide chains.

Ricinus agglutinin consists of two linked heterodimers and has a molecular weight of approximately 120,000. Each heterodimer consists of two polypeptide chains, an A' chain (molecular weight 31,000) linked by a single disulphide bond to B' chain (molecular weight 34,000). As in the case of ricin chains, the A' and B' chains of agglutinin are believed to contain one

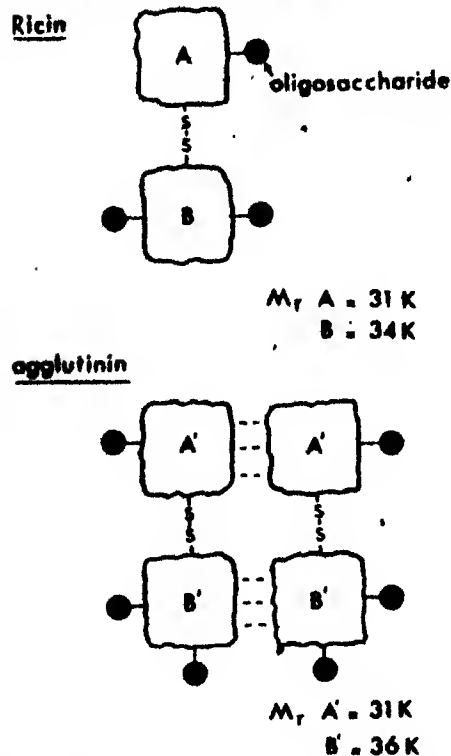


Fig.1. The structure of ricin and *Ricinus communis* agglutinin. (M_r values derived for glycosylated polypeptide)

and two oligosaccharide moieties, respectively (Fig.1)

Toxic effects

The toxic effects of ricin are entirely caused by the A chain. The B chain plays a vital role in that it is via the B chain galactose binding site that ricin interacts with cell surfaces and A chain is transferred into the cytosol where ribosome inactivation occurs. Separated A and B chains are essentially non-toxic. The toxicity of ricin is the result of three sequential steps. In the first step, binding of the whole molecule to the cell surface via the B chain occurs. Ricin binds reversibly to any suitably exposed galactose residue of a glycoprotein or glycolipid. The presence of a single ricin molecule within the cytoplasm can lead to cell death. However, an estimated several thousand molecules must bind to the cell surface in order to ensure the internalization of a single toxin molecule.

Any treatment which exposes the galactose residues of membrane glycoproteins leads to an increased sensitivity to the toxin. Similarly, cells having either a reduced number of

exposed toxin binding sites on the surface or an impaired ability to transfer bound toxin into the cytoplasm are ricin resistant.

The second step consists of internalization of the toxin molecule proper. The toxin molecules bound to cell surface are taken in by endocytosis. The mechanism by which endocytosed ricin is released or escapes into the cytoplasm is not known at present. It is known, however, that there is a significant lag period between ricin-binding to cells via a B chain galactose binding site and the actual decrease in the rate of cellular protein synthesis. The main part of this lag period represents the time the internal toxin molecules are contained in intracellular structures before being released into the cytoplasm.

The last step consists of the inhibition of protein synthesis. This is caused by the interaction of the A chain with the 60S subunit of eukaryotic ribosomes. Kinetic experiments have shown that pure ricin A chain inactivates ribosomes at a rate of about 1500 ribosomes per minute per A chain. Ricin chain appears to act by inhibiting the elongation factor (EF)-2 dependent GTPase activity of the ribosome. The 70S prokaryotic ribosomes are resistant to the toxin.

Ricinus agglutinin also inhibits protein synthesis although it has only about 1/30th of the activity of ricin. It too acts by inactivating ribosomes and it is the light chain (A' chain) which inhibits protein synthesis.

Synthesis

Synthesis of ricin and *ricinus* agglutinin occurs simultaneously in the endosperm cells of maturing castorbean seeds. Both A and B chain sequences are encoded by a single mRNA species. Translocation across the endoplasmic reticulum membrane is accompanied by the removal of an N-terminal signal sequence and by the addition of oligosaccharide chains to appropriate N atom of asparagine residues. This precursor is later transported from the endoplasmic reticulum to the protein bodies where it is cleaved endoproteolytically into proper subunits. This synthesis of ricin ensures that the native castorbean endosperm ribosomes are not inactivated by the toxic

A chains since the precursor is segregated into the lumen of endoplasmic reticulum during its synthesis. Significant contributions to the various aspects of ricin toxicity and its structure and synthesis have been made by the group of S. Olsnes at Norsk Hydro's Institute for Cancer Research, Montebello, Norway. [See: *The specificity and action of animal, bacterial and plant toxins*, (Ed) P Cuatrecasas, 1977].

Practical application

Recently there has been considerable interest in the construction of ricin based immunotoxins and their possible use in the therapy of cancer. Immunotoxins are conjugates prepared by covalently linking tumor specific antibodies to a plant or bacterial toxin. In principle, the toxic A chain of ricin once separated from the B chain would be unable to interact with and enter cells. If an alternative cell binding entity, such as an appropriate antibody, could be substituted for the B chain and joined to the A chain by a disulphide bond, a hybrid molecule would be formed for which the cell binding specificity has been changed but the toxicity due to A chain is retained. When the immunotoxin is directed against an antigen uniquely present or considerably enriched on the surface of a particular cell type, it should be possible to eliminate selectively these cells while leaving normal cells functionally undisturbed.

However, immunotoxins containing intact ricin molecule appeared to be more effective. This has been ascribed to the second function of the B chain, i.e., its ability to facilitate release of the A chain into the cytoplasm, in addition to its receptor binding function. But such ricin containing immunotoxins cannot be used because non-specific cellular interactions mediated by the B chain would eliminate the specificity conferred by the antibody. At present considerable efforts are being made to develop ricin based immunotoxins in which the putative A chain transport role of the B chain is preserved, while its ability to interact with galactose and thus cause non-specific interactions is eliminated.

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Monoclonal antibodies

ANIMAL serum contains a large number of antibodies against a host of antigens. A number of multiple antibodies may be produced against a single antigen. However, each antibody-producing cell is committed to the synthesis of a single antibody. In recent years, after development of hybridomas this property has been extensively exploited in the production of monoclonal antibodies. The word hybridoma is used to describe a hybrid cell produced by fusing sensitized spleen cells from a mouse with myeloma cells. By this fusion, it is possible to fix the transit expression of the individual cells in the form of permanent hybrid cultures which can be purified and stabilized by subcloning. The end product is a collection of permanent lines each producing a different monoclonal antibody. The monoclonal products need not be purified of unwanted antibodies as they have already been cloned out.

The hybridomas

The first hybridomas were obtained from spleen cells of mice immunized with sheep red blood cells which is, a very potent antigen. Two to four days after the last injection, the animals were sacrificed and their spleen removed. This is done when the number of antibody forming cells in the spleen is maximum. Lymph nodes

or bone marrow cells can also serve the purpose, but the spleen cells are the best source of a large number of B-cells.

In order to develop hybridomas against a particular antigen, the BALB/C mice (a strain of mice most suitable for producing antibodies) are immunized with antigen using Freund's complete adjuvant followed by another injection after 10-15 days in Freund's incomplete adjuvant. A week thereafter, the antibody production is tested by simple Ouchterlony or radioimmunoassay. The spleen cells are then made to fuse

with the myeloma cells of known genetic composition in the presence of polyethylene glycol (PEG). The hybrids are allowed to grow in a selective medium. The conditions allow only the spleen-myeloma hybrid cells to grow. The culture medium contains hypoxanthine, aminopterin and thymidine (HAT). HAT medium is used to ensure that only the hybrids will grow in culture. The popular strategy is to block the biosynthetic pathway for purines and pyrimidines by the folic acid antagonist aminopterin. The cell can still synthesize DNA by the 'Salvage pathway' in which the preformed nucleotides can be recycled. This pathway depends upon the

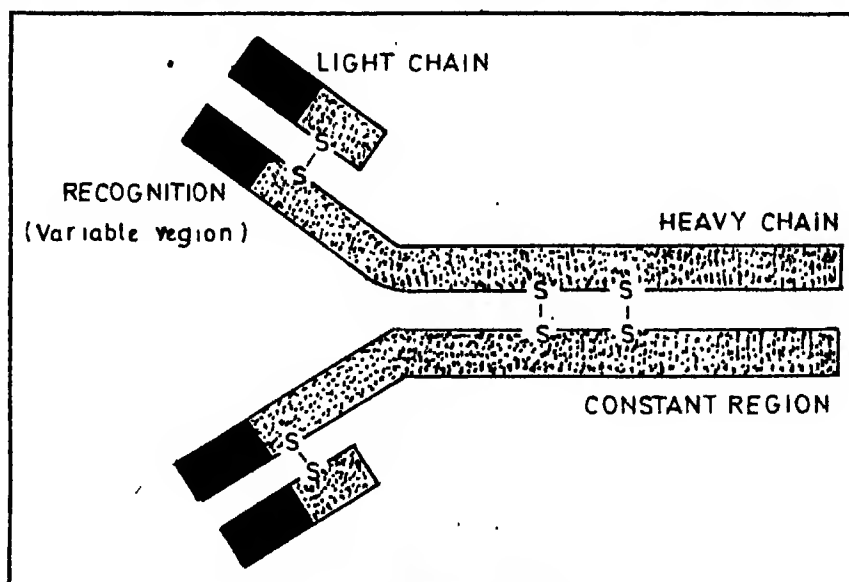


Fig. 2. Antibody molecule

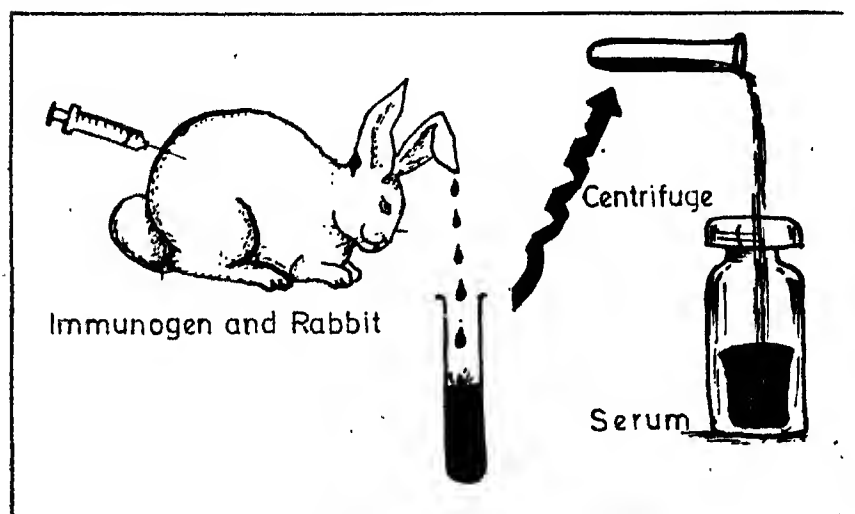


Fig. 1. Conventional antibody technology

enzymes—thymine kinase (TK) and hypoxanthine phosphoribosyl transferase (HPRT). Thus, if the cell is provided with thymidine and hypoxanthine, DNA synthesis can take place provided the enzymes TK and HPRT are present. The absence of either of these enzymes stops the synthesis of DNA. Two weeks later when the hybrids have grown considerably the antibodies can be screened. Once a positive hybrid is spotted, it is cloned to avoid overgrowth by other hybrids. After subclones are screened to identify the ones producing monoclonal antibodies, a few of each are grown to mass culture, frozen for future recovery and injected into mice to generate

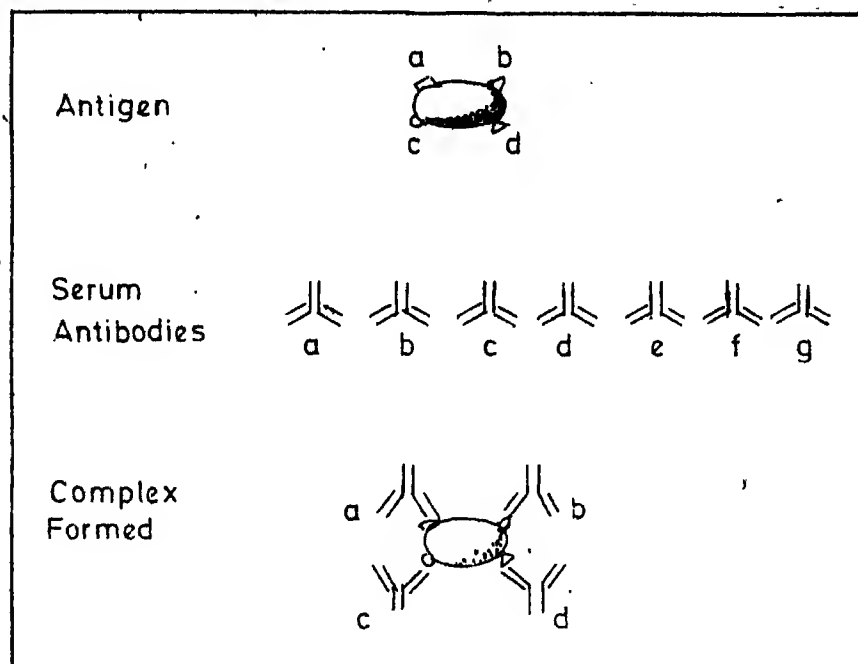


Fig. 3

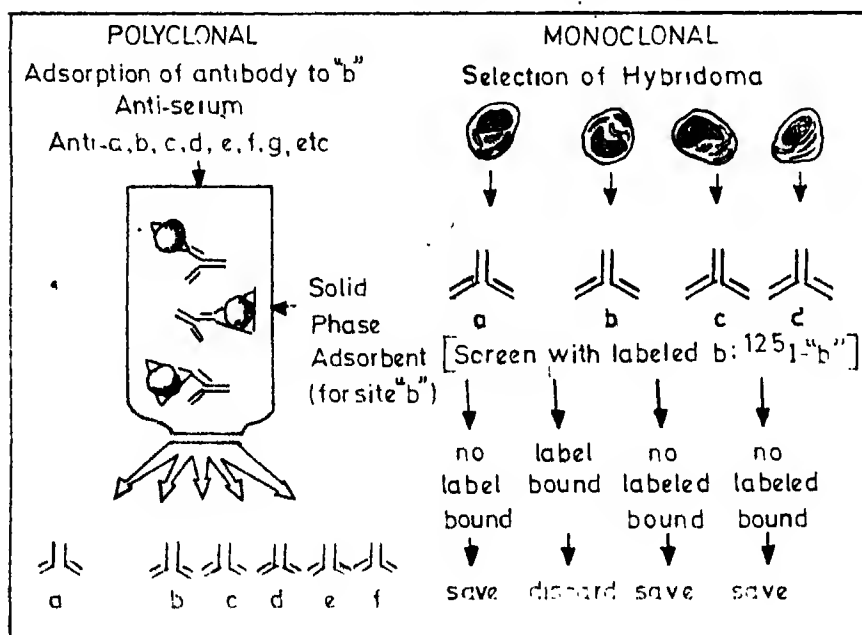


Fig 4

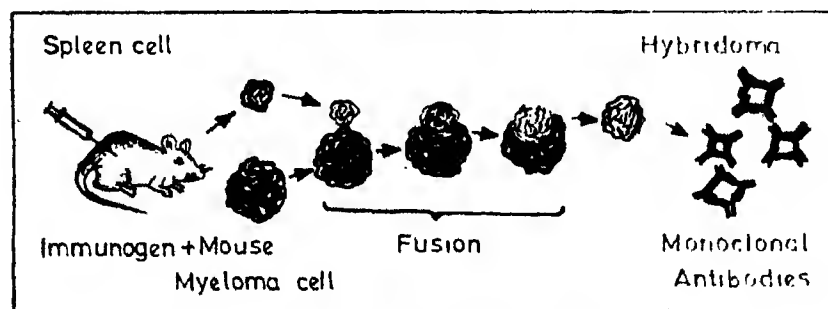


Fig. 5. Genetically engineered antibodies

more antibodies for extensive experimentation.

Human monoclonal antibodies

Currently human monoclonal antibodies have been generated. The two major technical problems encountered are the selection of human cell lines that can be used as a malignant partner in cell fusion and to obtain an adequate number of human lymphocytes immunized to the desired antigens. A drug marked human myeloma cell line has been successfully fused with immune spleen cells to produce antibody forming hybridomas. Human monoclonals are preferable in treatment of situations that are less life threatening.

Once the monoclonal antibodies are obtained, it is easy to purify even difficult antigens. The antibody can be immobilized on solid supports, such as cyanogen-bromide activated sepharose, to make an affinity column. Even membrane bound antigens have been purified on such columns by solubilizing the membranes in detergents that do not interfere with antigen-antibody binding. Elution can be easily carried out with mild acid or alkaline treatment which preserves their biological activity.

Uses

The use of monoclonal antibodies has spread to many areas of biological research and clinical medicine. They are replacing the antisera and many commercial companies are beginning to market them. They have made an impact in areas like cancer, virology, parasitology and bacteriology.

They have proved to be extremely useful in generating and detecting single amino acid substitutions in influenza hemagglutinin, in mapping antigenic sites on proteins, in studying the mechanism of antigenic drift, in classifying sub-strains of viruses and in studying their epidemiology. Their usefulness as probes of molecular fine structure has led many workers to generate monoclonals against other viruses and infectious agents. The structural proteins of Herpes Simplex types 1 and 2, murine

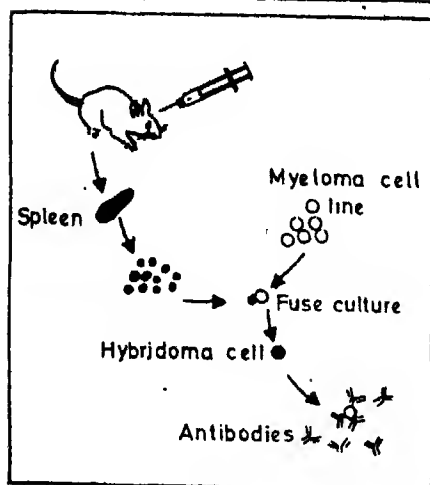


Fig. 6

leukemia, dengue and measles viruses have been examined.

Monoclonal antibodies have been raised to counteract various parasites like *Trypanosomes*, *Theileria* and *Schistosomes*. These parasites have specific antigens on their surface (tegument). *Trypanosomes* possess a highly immunogenic surface coat glycoprotein which undergoes antigenic variation and has been called the variant specific surface area or VSSA. Monoclonal antibodies have been raised against the VSSA of *Trypanosome* species.

The hybridoma technology can generate antibodies against impure and even unknown antigens. The extreme specificity of monoclonal antibodies makes one clonal product identify only one target molecule. Hence, they can be used to identify and purify a host of previously unknown molecules. They are also invaluable in the classification of cells. The hybridoma technology has been used to generate antibodies against human tumour associated differentiation antigens. Mice are immunized with intact human cells that are thought to contain a distinctive antigen. Hybrids are screened for antibody reactive to immunizing cells. The monoclonal antibodies thus generated have been used to recognize antigens associated with human leukemia, lymphoma, melanoma, colorectal carcinoma and neuroblastoma. Monoclonals can be used for diagnosing tumours of the central and peripheral nervous systems. They can be used in the therapy

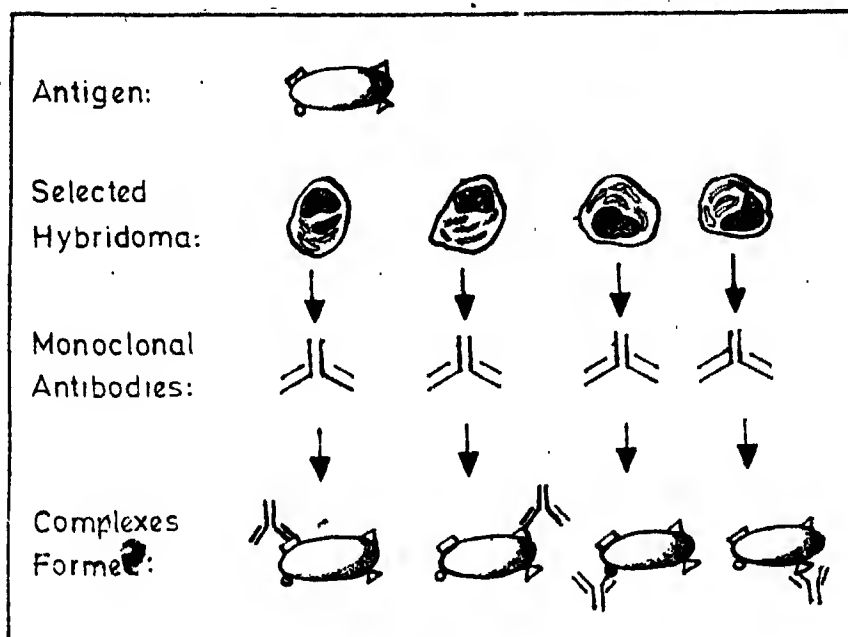


Fig. 7

of murine leukemia against differentiation antigen. The possibility of their use in direct therapy is being seriously explored in several directions. Also, they can be used as carriers of toxic substances for specific treatment of tumours. They may be used with radiolabels to identify tumours and for targetting of cytotoxic drugs to tumours or other tissues. Monoclonal antibodies of certain sub-classes may be used for the treatment of allergies.

Monoclonal antibodies can be used for characterization of surface antigens during childhood. Recently, monoclonal antibodies have been used to target the somatic cell mutants. Such mutants can be selected in tissue culture and used to study their structure-function relationships.

In short, success of hybridoma technology has established that the cell fusions can establish cell lines that can carry out their immunologic functions too. Thymus-derived lymphocytes have been fused with normal T-cells to generate functional cell lines. Functional hybrid lines of B-cells, T-cells and macrophages can be used to reconstruct the immune response *in vitro* with homogenous population of cells. This approach can be used to establish cell lines that would produce growth factors, hormones and other differentiated cell products.

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Date palm—"the tree of life" in desert

"KHAJUR", botanically known as *Phoenix dactylifera* L., belongs to family *Palmae*. It is a large woody dioecious monocot with the male (staminate) and female (pistillate) flowers produced on separate palms. The palm when mature reaches about 40m height. Because of its very nature the Arabs have a proverb, "The date

palm must have its feet in water and its head in the fires of heaven." Its leaves are pinnate, leaflets 20cm-40cm long and leaf stalk laterally compressed almost flat. The stem is cloined with the persistent basis of leaf stalks. Its flowers are unisexual, male pennicles white, compact and 9cm-14cm long. Inflorescence stalk

SCIENCE SPECTRUM

is short with female spike 18 cm-36 cm long. The fruit is 3 cm-6 cm long, reddish or yellowish brown when ripe with flesh thick and sweet. A dense mass of root suckers arises from the base of the stem. The date palm are always propagated by suckers or offshoots that arise from lateral buds which bear fruits of the same quality as the mother tree.

Date palm was cultivated by Sumerians as early as 3000 B.C. and it contributed so much to the material needs of the early people. It was considered a symbol of fecundity and fertility. To the Sumerians, the date palm was a tree of the knowledge of good and evil. Veneration for the date palm became particularly marked among the Semitic people of the desert, who recognised their dependence upon it. No other plant contributed so much to make the desert habitable. It is in a very real sense a "Tree of life" in the desert. The antiquity of it is proved by the fact that in Egypt the words "sweet and date" are identical. The most prosperous and oldest area in the world is the one along the bank of Shatt-al-Arab in southern Iraq. In India, its main centres of cultivation are Rajasthan, Punjab, Uttar Pradesh, Saurashtra and Kutch. Punjab and Rajasthan are considered suitable for date cultivation.

Economic Importance

The date palm supplies a large proportion of products. All the parts of the plant are used by man. The fruit is well-known for its sweetness. It is not only used as a fruit but also as a staple food in Egypt, Arab, Iraq and Iran. Syrup, alcohol and vinegar are derived from the fruit. The fresh sap is known as lagmi from which a beverage comparable to the juice of sugarcane can be prepared. The Arabs call it the drink of life. A fermented maceration of date yields the famous 'arrak' which Pedro Texeira, a sixteenth century traveller, described as the "strongest drink ever invented."

The fruits have been found to contain small amounts of vitamin A₁ and vitamin B₁ and B₂, are a good source of nicotinic acid. When a palm is cut down, the tender terminal bud is eaten as a vegetable or salad. The leaves are woven into mats, baskets,



Fig. 1. Date palm (*Phoenix dactylifera* L.) : Habit

fans, etc. The leaf stalks are used for making walking sticks, crates and baskets. The logs supply crossbeams for ceilings, posts for other structures and sweeps for wells.

The seeds are ground and fed to camels.

Climate

The area of western Rajasthan is a typical locality in India where the climatic conditions are favourable for date cultivation.

The successful cultivation of date palm requires:

(a) A long summer with high day temperature (up to 50°C) as well as high night temperature.

(b) A mild winter (up to a fall of 22°C for a short period without frost).

(c) Absence of rain at the time of flowering and fruit setting with low relative humidity and plenty of sunshine.

(d) The proper ripening of fruits requires a mean temperature of 21.1°C-26.7°C for at least one month.

(e) High atmospheric humidity is an important factor and humidity over 70% does not interfere with pollination or ripening.

Date palm can grow and produce fruits well on a wide range of soils varying from light loam to heavy clay, but for maximum growth and fruit production it requires an abundance of water.

Varieties

The varieties of the date are generally divided into three groups according to the flesh of the fruit, viz., soft, semi-dry and dry. The soft dates have a relatively less sugar content and high water content, whereas the semi-dry possess a high sugar content and a low water content. The dry dates have a higher sugar and a very low water content.

A few important varieties of date palm are:

(i) *Hillawi*. This variety was introduced from Iraq and gives good yield. It is in between the soft and semi-dry and is grown all over the world. This is an early maturing variety and is tolerant to rains and high humidity. The plant starts flowering and giving fruits at its young stage.

(ii) *Khadrawi*. Originated from Iraq, it is the earliest maturing variety. The fruit setting starts very early after cultivation. The tree is small but gives good yield.

(iii) *Zaidy*. It is also a semi-dry date from Iraq. The yellow fruits are taken fresh.

(iv) *Shamran*. This semi-dry date is a good yielder. In doka stage it is astringent and is not much relished.

(Continued on page 118)



MEDICAL NOTES

t-PA: a new hope to patients of heart attack

A natural product called t-PA (tissue-plasminogen activator) for stopping heart attacks by dissolving blood clots has passed through first clinical tests. Out of seven patients with spasms of heart attack during trial with this substance, six showed that the blood clot, causing heart attack, disappeared within an hour. According to Dr. Philip Ludbrook, Professor of Medicine at Washington University, St. Louis in Missouri, the promise of t-PA lies in minimising the damage of heart attack by restoring blood flow to heart muscles quickly.

About ninety per cent of heart attacks are caused by blood clots or thromboses clogging coronary arteries, specially at the sites of build up of fat deposits called plaques. A high natural fat diet elevates plasma cholesterol level. The infiltration of cholesterol into certain lesions of arterial walls distorts blood vessels and makes them rigid. This hampers the normal blood flow. Such areas are particularly prone to thrombosis because slow blood flow permits activated blood coagulating factors to accumulate instead of being washed away. The activation of blood coagulating factor XII (Hageman factor) occurs when the inner lining of the blood vessels is damaged by arteriosclerosis and blood comes in contact with collagen fibres present in the wall of blood vessels. The activation of factor XII activates factor XI and this leads ultimately to formation of fibrin which causes thrombosis (Fig.1). The blocking of coronary artery or its branch by circulating thrombus may occur at the site where arterial passage has been reduced

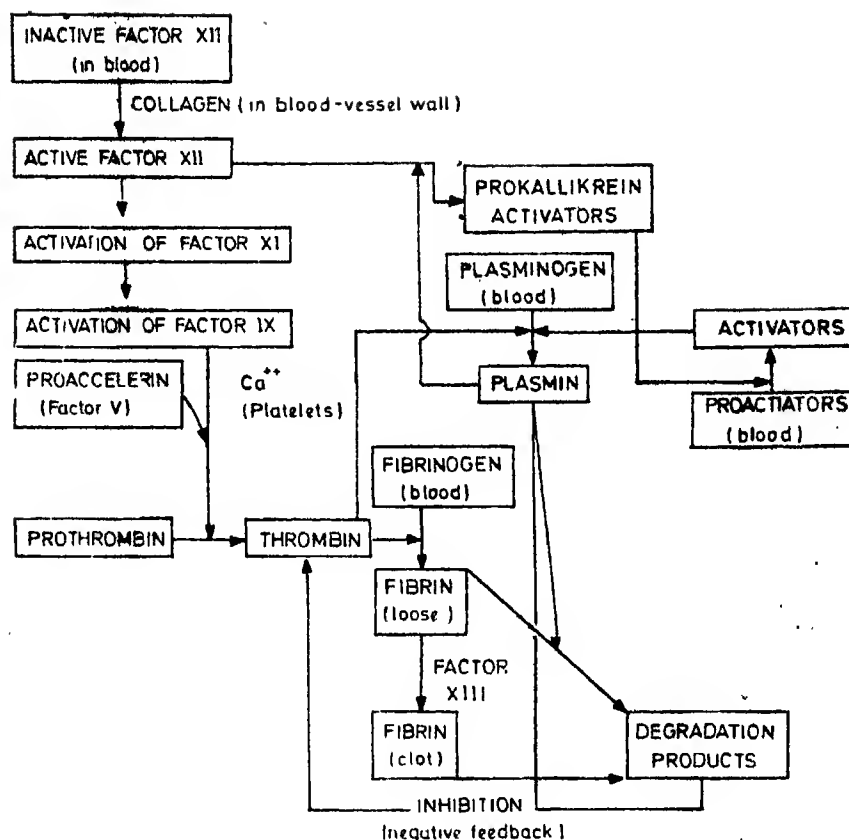


Fig.1

due to plaque formation. Such blockage results in reduced blood supply to myocardium. As a result the cells are deprived of oxygen leading to death of myocardial tissue. If a large branch of coronary artery is blocked, this may lead to the necrosis of a large area of ventricle causing ventricular fibrillation and thereby stoppage of its work which causes instant death. However, occlusion of a small branch may cause less damage and corresponding reduced severity of heart attack.

In case of heart attack, it is of utmost importance that the thrombus is removed immediately so that the blood supply to myocardium is restored. Commonly heparin and urokinase are used clinically for this purpose. Urokinase is found in the urine but is very expensive to extract. A complete course of treatment using urokinase extracted from 5000 litres of urine costs £5000. Heparin acts as an anti-coagulant by preventing factor IX (PTC-plasma thromboplastic component) and, in conjunction with

plasma cofactor, it inhibits formation of thrombin. Thrombin is essential for clotting of blood since it brings about formation of fibrin from fibrinogen. The inhibition of thrombin formation by the activity of heparin on factor IX may lead to unusual bleeding elsewhere in the body. Urokinase activates the inactive form plasminogen in blood to the active form plasmin. Plasmin attacks both fibrin and fibrinogen and forms their degradation products which in turn inhibit thrombin activity. Therefore, urokinase dissolves fibrin clot and also attacks fibrinogen in blood disturbing the normal coagulating mechanism leading to uncontrolled haemorrhage in the body. t-PA also works by converting plasminogen to plasmin but acts on fibrin specifically and only attacks the clot without disturbing clotting mechanism.

t-PA used in the US study was extracted from cancer cells. An immediate treatment with this substance not only stops heart attack but also improves working of the heart

MEDICAL NOTES

and overall chances of survival. Trials of t-PA treatment reported in *New England Journal of Medicine* (Vol. 310, p. 609) show that if the patient is treated within seven hours of the onset of chest pain, the chances of survival are greatly increased.

t-PA is normally produced in small amounts in a number of human tissues including cancerous cells which are the main source of this substance at present. However, attempts are being made to develop genetically engineered t-PA in bacteria. Gene

technology has received a clearance from American Food and Drug Administration to test genetically engineered t-PA on human beings.

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PLASMA MEMBRANE (Continued from page 73)

deliver drugs and enzymes to patients of metabolic disorders, and hormones like insulin to diabetic patients. Importance of liposomes in medicine lies in their two properties: firstly, they provide protection to the encapsulated material against digestive enzymes (when administered orally) and secondly, liposomes release the entrapped drug very slowly and gradually into the tissue(s). In tissues, liposomes are believed to be digested by enzymes, thereby releasing the therapeutic agent. However, to make target-specific liposomes further research is necessary.

In conclusion, lipid bilayer of membranes is a powerful barrier against the entry of charged and polar molecules inside the cell. However, such molecules are selectively transported

across a plasma membrane by proteins functioning as the solute carriers. Under stress conditions, changes produced in membrane phospholipid composition affect functioning of membrane proteins, which, in turn, regulate cellular metabolism. Therefore, a correlation does exist between the type of predominant lipid species present and the nature of function it performs for a cell.

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TRANSITION ELEMENTS IN BIOLOGICAL SYSTEM (Continued from page 86)

known molybdenum containing metallo-enzymes. Several others like sulphite oxidase, aldehyde reductase and nitrogenase are also known to play vital roles in many biological processes. Its essentiality for fungi, blue-green algae and plants is also well recognised. Although it is an essential element in human and animal nutrition, its specific role is not well established.

Trace element deficiency and excess

A recent trend in medicine has been to assign symptoms of a disease to the deficiency or excess of one or more trace elements. Consequently there has been an increasing recognition of the importance of trace elements in biological systems. Table 2 summarises some of the symptoms

and diseases attributed to the deficiency and excess of trace elements.

It may also be pointed out that even "polluting" metals such as cadmium appear to have beneficial properties when present in an extremely low concentration. On the other hand, even a so called harmless metal such as aluminium can be dangerous if present in a high concentration of a bioavailable or non-extractable form. This suggests that our efforts to regulate concentration of each metal should be limited to maintaining its level within a "concentration window" wherein enough is present to avoid a nutritional deficiency but not high enough to be toxic.

Conclusion

Bioinorganic chemistry has not yet been able to provide sufficient vital

background information needed for foolproof cure of various diseases caused by excess or deficiency of the trace elements, but the current research in this area is attracting increasing attention around the globe. Time is not far off when we would be able to locate, detect and regulate a problem element before it causes a serious health hazard.

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SCIENCE FOR THE YOUNG

Florence Nightingale—the nurse extraordinary

THE very word "Nurse" evokes the image of Florence Nightingale, a charming, kind and motherly woman who used to take special care of ill and wounded soldiers. Her image of "lady with a lamp" not only inspired poets to write poems and songs praising her thankless work but also brought tremendous respect to the profession of nursing. But this is all what is generally known about her and her contributions to medical science. It is not at all known beneath her charm and kindness was an indefatigable fighter, a woman who meant business. She not only showed that nursing was a mission and not simply a profession but she also brought about a revolutionary change in administration of hospitals. Her contributions are remarkable especially in those days of Victorian England when the purpose of women was simply to get married and rear children. But the least known of her achievements is that she was a pioneer in using statistics in medical science. She believed that statistics can easily be used for forwarding compelling arguments for the betterment of medical treatment and facilities. In fact, in the field of statistics itself, she is considered to be the inventor of a new technique of presenting data to the public.

Florence was born with a silver spoon to Fanny and William Nightingale on May 12, 1820. Nightingales were wealthy people who owned a large estate and a number of houses in London and various towns. Her father was a quiet man who liked reading and abstract speculation and also did hunting and fishing. Florence had his cast of mind but her very

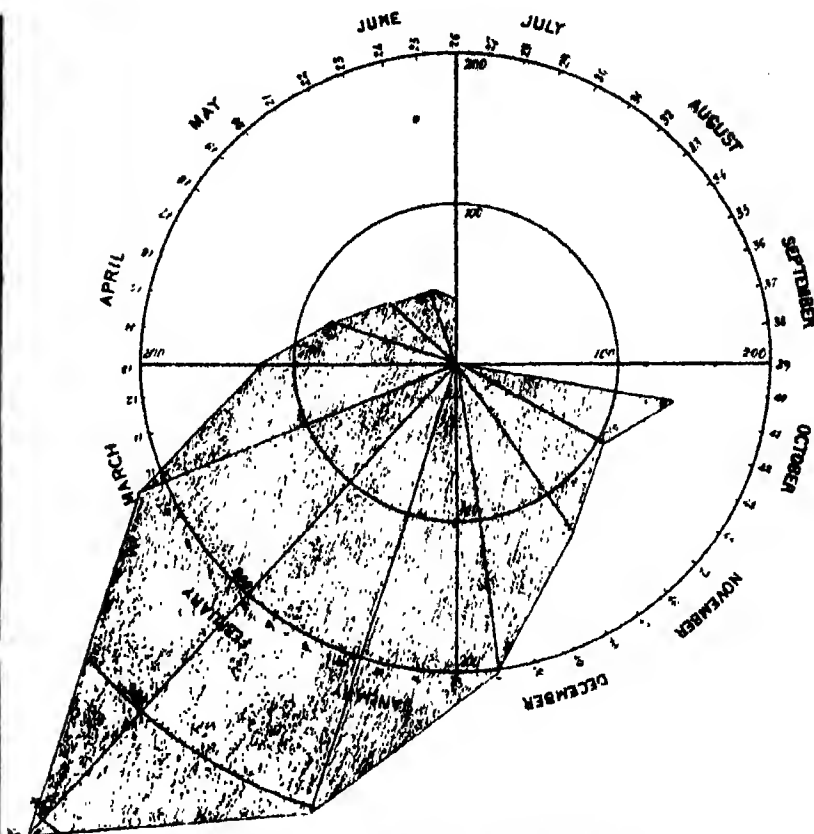
name was after the Europe's most gay city which her mother, a society lady, loved the most in her life. So, her childhood was spent in attending her mother's drawing room parties, picnics and balls and also in learning various languages, history and philosophy from her father. Nevertheless, her bent for serving the ill and wounded was apparent even when she was a child. She used to doctor her dolls, nursed pets during their sickness and took a special care of babies.

When Florence was about to enter the youth of her life, she had the fine intellect of her father and the charm of her mother, a blend which was likely to make her the most sought after girl in high society circles of those Victorian times. And her ambitious mother wanted her to be a social success and marry her off to a man of fortune. But she was unaware of the changes that had appeared in her daughter in the meanwhile. One of the early influences was the Italian historian Sismondi who was living as an exile in Geneva. In his presence young Florence felt that his high purpose of serving his country and unflinching integrity was worthy of emulation. Her dreaming nature stimulated her to think of herself as a heroine fighting a just cause for the benefit of the mankind. The starvation and death that plagued England in 1842 further made a deep impression on her mind. Starvation and suffering did not shock her so much as the indifference to misery that followed in their wake. Meanwhile, the bug of mathematics had bitten her. She found the subject highly satisfying and felt that it gave her a sense of certainty. To top it all, she had a "mys-

tical" experience when she was hardly 17. She felt that God had talked to her and had called her in His service. In course of time, Florence realised that she was living a wasteful life. "All I do is done to win admiration", she once wrote. At last after much groping and introspection, she found that her place lay among the sick and poor. When she finally declared her aspirations to serve as a nurse in a hospital, her parents and elder sister were shocked. There followed terrible scenes in her home but she was obstinate and refused to yield. In those days, no respectable woman opted for nursing as a career. Not only nurses were women of questionable character and were drunkards but hospitals were also the centres of dirt, insanitation and squalor.

Florence was so keen to take up nursing profession that she began to visit hospitals, infirmaries, alms houses, institutions, etc., of several European countries and began to study the situation of nurses on the spot. She used to watch how doctors examine patients, how operations were conducted, what were supposed to be the duties of a nurse, so on. She also collected all kinds of reports, studies and statistics on the organisation of hospitals and nursing arrangements. On the basis of her studies she arrived at the conclusion that most nurses were either widows with large families to provide for or women of dubious past both being prone to dishonesty. Moreover, she felt that the role of nurses could be made much more effective if their duties were to provide patients with clean beds and good food rather than simply to keep a watch on them through their sickness. She also joined a convent of nuns in Paris to find out the secret of inspiring women to live for a cause, a quality lacking in nurses. She had however a first hand experience of the confusion that prevailed in a hospital of those days when she volunteered to work as a nurse in Middlesex Hospital at the time London was reeling under a cholera plague. But her real success came into prominence when the Crimean War broke out in 1854.

The Crimean War is known to have marked a new epoch in journalism when *The Times* correspondent W.H.



Florence Nightingale (Photo : B.I.S.). On the right is the Polar graph devised by her to present medical data. She drew this particular graph to show the sharp decline in mortality rate at Scutari hospital, thanks to the sanitary reforms brought into force at her instance (Courtesy : Scientific American)

Russell began to send his dispatches on the state of war from the front in Turkey. Although the allied forces of Britain and France won the battle of the Alma river, he reported, it turned out to be a tragedy for the wounded and sick soldiers who were left behind without any aid due to scarcity of transport means. His dispatches naturally caused anger against the war authorities and sympathy for soldiers. *The Times* therefore raised a relief fund which was handed over to the War Office for action. Nightingale and a party of 40 nurses were therefore sent to Scutari, a big village on the Asian shore of Bosphorus. The hospital at Scutari was originally a Sultan's palace which stood on sewers full of filth. When Nightingale and her party reached the hospital, utter chaos prevailed there as cholera had also struck the already ill and wounded soldiers. There were no bandages, no splints, no chloroform and no morphia not to speak of clean linen and sheets. In absence of candles and lamps, surgeons performed operations in moonlight!

It did not take long for Florence to realise that she and her party of nurses were uninvited guests in the hospital. Doctors and surgeons totally ignored her presence. They felt that she was simply a well-bred nuisance who had been foisted upon them. Some even thought that she was a government spy sent to keep a watch on them. Florence therefore decided to keep mum and waited on an opportunity to show her mettle. And the opportunity came when a fresh batch of cholera-stricken soldiers poured into the hospital turning the place into utter confusion. Her help was immediately sought and she showed herself worthy of the confidence shown in her. She took the entire management of the hospital in her own hands. *The Times* Fund available at her disposal further enabled her to take her decisions free from any bureaucratic restrictions. To make available clean linen and sheets, she established her own laundry. She also installed a kitchen to prepare food for the sick and wounded. She took charge of all

kinds of supplies that were required in the hospital—from sheets, socks and food to medicines, chests and beds. Besides, she also took personal interest in all soldiers. When everybody was fast asleep, she used to take rounds of the hospital alone with a lamp in her hand. Within six months, the mortality rate at the hospital fell from 42.7 per cent down to 2.2 per cent! Soldiers began to worship her. Her fame reached England when soldiers returning home talked about her in their families. Legends grew and proliferated. Poems and songs were written and sung in her memory. New babies, ships and even horses were named after her.

The Crimean War not only made Florence a legendary figure for all time to come but also changed her personality for the rest of her life. After seeing the horrors and miseries of the war, she had become a haunted lady. Although the British Government sent a man-of-war to pick her up, various military bands waited on her to accompany her home, several receptions and public meetings were to be held in her honour, she refused

everything. In fact, she managed to reach England under a disguise. Although the changes that she had brought about in nursing were revolutionary, she herself felt that her cause had been defeated especially due to the publicity showered on her. She found that the concerned military authorities were then more hostile to her ideas of sanitary reforms in their hospitals because she was a lady and a heroine to boot. She got the opportunity to present her sanitary reforms backed by facts and figures when she met Queen Victoria and Prince Albert at Birk Hall, and was presented the St. George's Cross for her services. Unfortunately, her reforms got tangled up in bureaucratic rigmarole. It took more than a decade of persistent efforts on her part to bring those reforms into practice. In the meanwhile, money began to pour in from all over the world in the cause of nursing. Eventually, the Nightingale School of Training Nurses was established with the primary goal of furthering Florence's ideas of sanitary reforms in hospitals.

Since her return from the Crimean War, Florence lived the life of a recluse—and an invalid at that. It is said that she had contracted some disease during strenuous work at the Scutari hospital. She had always had the feeling that she was likely to die soon and wanted to do as much as she could so that she could die in peace. She therefore always overexerted herself. One can imagine her activities from the fact that she kept regular correspondence with nurses, doctors and surgeons all over the world and also visited hospitals, infirmaries, prisons, barracks, etc., to collect data and to watch where the things were going wrong. Her prodigious amount of work appeared in her later life in form of small pamphlets and then books on various aspects of nursing, hospital administration, child care and health, etc. Although a woman in her position was offered several special privileges, she declined all and lived like an ordinary citizen. When she died at the age of 90 years, her body was buried without pomp or show in the family grave. A simple cross with her initials "F.N." marked her grave, as per her will. Only a few years before her death, the International Conference of Red Cross Societies hailed her as the pioneer of the Red Cross movement.

What were Florence's contributions to medical science and statistics? First of all, she brought in revolutionary changes not only in nursing profession but also in the attitudes of nurses towards patients. She evolved a code of conduct for nurses. For instance, she made it compulsory for all nurses, whether belonging to high or low families, to live together, have a uniform dress, so on. She also made the position of a nurse subservient to doctors and surgeons. She believed that nurses should not simply consider the treatment of a patient's body to be their sole duty but also his or her soul. She also suggested the use of various gadgets, such as "bell" and "bulbs," to reduce the peon work a nurse had to do. Her sanitary reforms in hospitals were taken up all over the world in course of time and reduced the rate of mortality. She even thought that hospitals should be designed in such a manner that they follow the elementary principles of

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sanitary science. For instance, hospitals should have better ventilation, better drainage, and better food should be served to patients. Her studies showed that a large cubic meter of breathing air per patient should bring down the rate of mortality in hospitals. She was therefore consulted in designing several hospitals, including the General Hospital, Madras. Although she ignored the then newly established germ theory of diseases, her reforms in hospitals conformed with the theory. She also advocated hospitals to follow uniform methods to collect data and also to have uniform policy of naming diseases. In fact, at the newly formed International Congress of Statistics held in 1860 her scheme for uniform hospital statistics was the principal subject for discussion. In statistics, she invented what is now known as the "Polar area charts" to present statistical data in an easily understandable manner.

Dilip M. Saini

Cork : a material with unusual qualities

CORK is the bark of 'cork oak' tree which flourishes only in the area surrounding the western Mediterranean sea. Cork is a material of unusual versatility because it is endowed with many desirable properties which are not found together in any other single material.

Cork is a very light material. The density of natural cork is only about a quarter of the density of water. Corkboard, which is made from granules of pure cork by a special process and is available in slab form, is lighter than natural cork. Furthermore, the thermal conductivity of corkboard is incredibly low. This makes it an extremely efficient thermal insulator and has also earned it the distinction of becoming the recognised standard of comparison for all low-temperature insulating materials.

The compressibility of cork is very high. Cork mountings have been deflected upto 24% without showing any noticeable bulging (lateral expansion). This is in sharp contrast to the behaviour of rubber whose volume compressibility is extremely

low. If this seems contrary to common notion, it may be pointed out that a block of rubber when compressed in one direction invariably bulges out in other directions so that its volume remains essentially the same.

The high compressibility of cork, together with its high resilience (tendency to spring back to normal shape after deformation), makes it particularly useful for isolation of vibration. For this purpose, special grades of corkboard, are often installed on the sides or under the concrete foundation of heavy machinery.

Cork does not have the blotting-paper effect which causes materials of fibrous composition to absorb water. Absorption of water usually results in swelling and leads to gradual decay of materials. Cork is remarkably free from these problems.

Cork is an excellent acoustic material (noise absorber). Cork tiles have a sound absorption coefficient of 0.35 to 0.45 which means that the acoustic tiles can absorb as much as 35 to 45 per cent of incident sound energy.

SCIENCE FOR THE YOUNG

Cork is a fire-retardant material. It will not catch fire from sparks and can only be ignited by a flame.

Many of the desirable properties of cork are directly attributable to its unique cellular structure. Instead of being fibrous as is the bark of many other trees, the bark of cork oak is composed of minute cells. These cells are so small that they can be seen only under a high-power microscope. Incredible as it may seem, there are more than 10 million cells in a cubic centimetre of cork. Each cell is filled with air. Next only to vacuum, air is the best insulator known. The low thermal conductivity of cork is

due to the presence of these innumerable air-filled cells.

Cork cellular structure, also makes it free from the malady of water absorption.

The excellent noise-reducing ability of cork is also due to its cellular structure. Air inside the minute pores is set vibrating by incident sound waves. Friction of this motion against walls of the pores generates heat. Part of the sound energy is removed as heat, while the remainder is reflected and transmitted. In this manner, effective noise-attenuation is achieved.

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Squares of numbers and their reversals

THE two-digit numbers 12 and 13 when squared generate the numbers 144 and 169 respectively. If we take the squares of the reversals of these numbers the results also get reversed. Thus,

$$12^2 = 144$$

$$21^2 = 441$$

and

$$13^2 = 169$$

$$31^2 = 691$$

Incidentally, 12 and 13 are the only two-digit numbers which behave in this way. It will nevertheless be interesting to examine if there are any higher numbers, with digits greater than 2, which also behave similarly.

First, let us limit our search to three-digit numbers. Let such a number be $xyz = 100x + 10y + z$. We assume, for simplicity, that the squares of the digits x , y and z of the number are single-digit numbers so that the maximum values of x , y and z cannot be greater than 3. We can then write for the square of the number xyz ,
 $(100x + 10y + z)^2 = 10,000a + 1,000b + 100c + 10d + e$

where a , b , c , d , e are the digits of the resulting square number from the left.

On reversing the number xyz and taking its square the equation that results is

$$(100z + 10y + x)^2 = 10,000e + 1,000d + 100c + 10b + a$$

From the above equations, we have the following identities:

$$x^2 = a, 2xy = b, 2xz = c, 2yz = d, z^2 = e$$

In order to solve these identities we note that x and z in particular can only take the values (1,2); (2,1); (1,3), or (3,1). The combinations (1,1); (2,2) and (3,3) are automatically eliminated as they only lead to some trivial three-digit palindromic numbers. The combination pairs (2,3) and (3,2) make $c=12$ and, therefore, have to be ruled out.

Once we have been able to fix the values of x and z , the acceptable values of y can be worked out easily from either of the following equations.

$$y = b/2x$$

$$\text{or } y = d/2z$$

It should be noted that for $z > x$ the value of y is obtained from $y = d/2z$ while for $x > z$ the relevant equation from which y is calculated is $y = b/2x$. For instance, for the pair $x, z = (1,2)$ where $z > x$ the values of y can be calculated from $y = d/4$. Obviously, d can be either 0, 4 or 8 and, therefore, the admissible values of y are 0, 1 or 2. The pair $x, z = (1,3)$ similarly gives for y the values 0 or 1. Thus, the three-digit numbers we were looking for the following five:

102, 112, 122, 103, and 113

These numbers were obtained by assuming that the limiting values of x , y and z cannot exceed 3. Relaxing this condition makes the treatment more complicated however. Without going into the intricacies of the treatment it suffices to remark that no additional

three-digit numbers exhibiting the same property can be found out. Can any reader supply a proof why this should be the case?

Finding out four-digit numbers that exhibit the same property is still more difficult. However, the author has been able to figure out the following twenty four-digit numbers which satisfy the requirement laid down by us:

1011, 1021, 1031, 1121, 1002, 1102, 1012, 1022, 1202, 1112, 1212, 1122, 1003, 1103, 1013, 1203, 1023, 1113, 2012, 2022

It may be noted that the sum of the digits in any of the above numbers does not exceed 6. Can anyone provide more examples by intuition or by following a logical method?

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Science quiz (Forestry)

- The most important timber tree of India is
 (a) Sal (*Shorea robusta*)
 (b) Shisham (*Dalbergia sissoo*)
 (c) Teak (*Tectona grandis*)
 (d) Deodar (*Cedrus deodara*)
- A tree which normally attains the largest dimensions is
 (a) Semal (*Bombax ceiba*)
 (b) Deodar (*Cedrus deodara*)
 (c) Teak (*Tectona grandis*)
 (d) Champa (*Michelia champaca*)
- The principal resin-producing pine of India is
 (a) Kail (*Pinus wallichiana*)
 (b) Khasipine (*Pinus insularis*)
 (c) Chir (*Pinus roxburghii*)
 (d) Chilgoza (*Pinus gerardiana*)
- Newsprint-making tree of India is
 (a) Salai (*Boswellia serrata*)
 (b) Eucalypts (*Eucalyptus hybrid*)
 (c) Paper mulberry (*Broussonetia papyrifera*)
 (d) Silver fir (*Abies pindrow*)
- The bidi leaf tree is
 (a) Sal (*Shorea robusta*)
 (b) Maljhan (*Bauhinia vahlii*)
 (c) Dhak (*Butea monosperma*)
 (d) Tendu (*Diospyros melanoxylon*)

A.C. Gupta

Research Officer

F.R.I. & Colleges Dehra Dun-248006

(Ans. on page 118)

6. Cutch and katha are obtained from
 - (a) Babul (*Acacia nilotica*)
 - (b) Khair (*Acacia catechu*)
 - (c) Phulahl (*Acacia modesta*)
 - (d) Semia (*Bauhinia retusa*)
7. Commonest matchwood of India is
 - (a) Gutel (*Trewia nudiflora*)
 - (b) Papita (*Pterocymbium tinctorium*)
 - (c) Sernal (*Bombax celba*)
 - (d) Kadam (*Anthocephalus cadamba*)
8. Most prized essential oil-bearing wood is
 - (a) Agar (*Aquilaria agallocha*)
 - (b) Deodar (*Cedrus deodara*)
 - (c) Chir (*Pinus roxburghii*)
 - (d) Sandal (*Santalum album*)
9. Most Important oil seed-bearing tree is
 - (a) Neem (*Azadirachta indica*)
 - (b) Karanja (*Pongamia pinnata*)
 - (c) Mahua (*Madhuca spp.*)
 - (d) Raini (*Mailotus philippensis*)
10. Most important tanning bark used in North India is that of
 - (a) Arjun (*Terminalia arjuna*)
 - (b) Babul (*Acacia nilotica*)
 - (c) Amaltas (*Cassia fistula*)
 - (d) Sal (*Shorea robusta*)
11. Commonly used timber for carving screens, furniture and trays is
 - (a) Haldu (*Adina cordifolia*)
 - (b) Gamari (*Gmelina arborea*)
 - (c) Kaim (*Mitragyna parvifolia*)
 - (d) Akhrot (*Jugians regia*)
12. Most prized wood for high class carving and inlay work is
 - (a) Shisham (*Dalbergia sissoo*)
 - (b) Red sanders (*Pterocarpus santalinus*)
 - (c) Rose wood (*Dalbergia latifolia*)
 - (d) Ebony (*Diospyros ebanum*)
13. Chief sports goods-making wood of India is
 - (a) Mulberry (*Morus alba*)
 - (b) Celtis (*Celtis australis*)
 - (c) Bola (*Morus laevigata*)
 - (d) Ash (*Fraxinus floribunda*)
14. Most widely used timber for scales for school use is

- (a) Toon (*Toona ciliata*)
- (b) Haldu (*Adina cordifolia*)
- (c) Mango (*Mangifera indica*)
- (d) Gamari (*Gmelina arborea*)

The long trek to absolute zero

ORIGINALLY the word 'Cryogenics' meant the study and generation of low temperatures. In recent years, however, the term has been used increasingly to mean a special branch of physics which essentially deals with phenomena related to supercold temperature conditions.

As a branch of science, cryogenics is not very new. It originated at the turn of this century when oxygen and nitrogen were separated from air by liquefying it and selectively boiling off the ingredients. Oxygen and nitrogen obtained in this way are now used in various industrial sectors as well as for research.

It was only after liquefaction of helium in 1908 that the real interesting features of cryogenics came to light. Liquefaction of helium may be rated as the final achievement in this particular line of efforts, as all other gases liquefy at considerably higher temperatures. So it is no wonder that after 1877, when oxygen was liquefied, it took almost three decades for scientists to master the technology of helium liquefaction.

It is worth mentioning here that liquefaction of gases one after another was not just an aimless game played by the scientists. On the contrary, the efforts were aimed at attaining the ultimate in low temperature—the absolute zero. It was first postulated by the French scientist Guillaume Amontons, who conceived the idea of some ultimate lowest temperature; from the gas laws its value was calculated to be -273°C . When this temperature was theoretically earmarked, it was natural to introduce a new scale, of which this would be the zero. The new scale widely used in cryogenics is the Kelvin scale of temperature.

Once the value of absolute zero was calculated theoretically, it became a matter of keen interest among experimentalists to achieve it in practice and the venture, seeming endless yet, started with the liquefaction of the gases one after another.

To answer the question whether we can ever produce absolute zero of temperature in the laboratory one has to go through certain theoretically established facts.

It is known that an increase in temperature of anything means an increase in the average kinetic energy of the molecules constituting it. Based on this idea, it was wrongly assumed that at absolute zero all the molecules of a substance would come to an absolute state of rest. This conceptual mistake was rectified in 1906 after Walther Nernst, a German Chemist, discovered a fundamental law of physics known as the Third Law of Thermodynamics. On theoretical grounds he was able to show that even for a substance at absolute zero the molecules might possess some energy, but, according to him, in so far as their motions are concerned, they must be in a state of perfect order at that temperature.

For example, in a gas at normal temperature the molecules are in a state of random chaos, restless and free to move in all directions. To bring them under perfect order one has to proceed step by step. In the first step this absolute disorder is modified to some extent when the gas is cooled down and then liquefied. To establish more order, in the second step, it is necessary to take out more heat to cool it further till it solidified. These successive changes establish more and more order. One can very easily realize that as matter changes from

SCIENCE FOR THE YOUNG

gaseous to liquid state and from liquid to solid state the motions of its molecules become more and more constrained, i.e., they lose freedom. This approach towards perfect order, i.e., absolute zero, as Nernst showed, has limitations. To achieve it in practice by the process of cooling will require an infinite number of steps and hence will never be achievable.

This concept, however, gives some effective hints to various means of generating very low temperatures. The method usually adopted for this purpose is to compress a gas isothermally and then allow it to expand adiabatically. Normal when a gas is compressed it usually gets heated, so for its isothermal expansion the heat has to be taken off so that after compression the order of the molecular motion does not decrease. If after this compression the gas is allowed to expand adiabatically, i.e., if during expansion no heat is allowed to enter, the net result is a gain in the order of the

molecular motions and hence a fall of temperature. As the cycle is repeated, the order increases step by step after completion of each cycle, till the gas finally liquefies.

Now, as all liquids are practically incompressible, some other process has to be adopted to cool it further. Temperatures below those attainable by gas liquefaction may be reached by a process called 'adiabatic demagnetization'. This method in fact brings order in the random orientations of electron spin. It is well known that due to their spin electrons behave like small magnets. Normally, these tiny magnets are randomly oriented even at temperatures as low as 1 K and to bring order in them one has to use a very strong magnetic field. This ordering naturally generates a heat of magnetization which has to be removed. This is normally done using liquid helium. After cooling, if the magnetic field is switched off without allowing the system to regain heat from outside

the temperature falls further. By successive application of this process a temperature as low as .003 K can be generated. Similarly by the same process, starting from a temperature not higher than .001 K with an ordering of nuclear spin orientations, one might theoretically obtain a temperature as low as .0001 K.

But the question remains; Even at this super cooled condition, how far are we from absolute zero? The answer is, as far as ever, since from this point also it would require an infinite number of steps to reach the ultimate goal!

Debabrata Mukhopadhyay
All India Radio, Siliguri
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Answers to science quiz

1. (c), 2. (b), 3. (c), 4. (a), 5. (c), 6. (b),
7. (c), 8. (d), 9. (c), 10. (b), 11. (d), 12.
(c), 13. (a), 14. (b)

SCIENCE SPECTRUM (Continued from page 110)

because of its low water content, the flesh of fruit becomes hard.

(v) *Deglet noor*. It is also a semi-dry date from Algeria and is the leading variety in the U.S.A. It is good for storage.

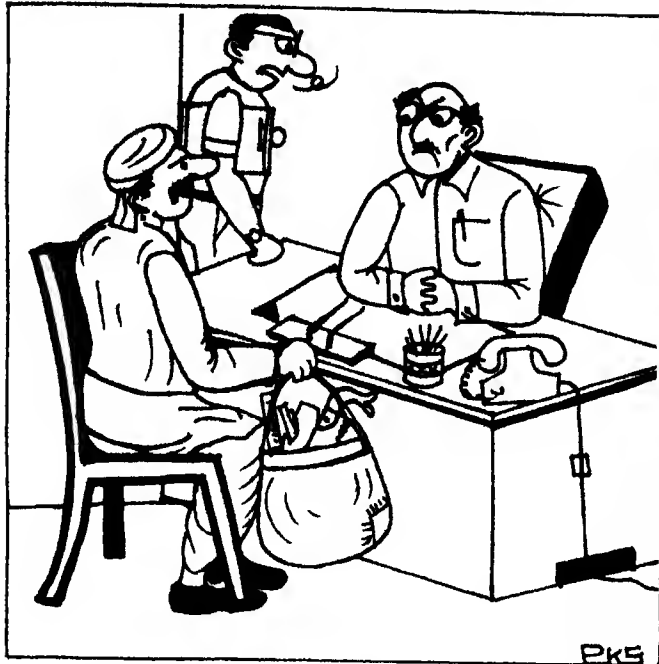
(iv) *Shamran*. This semi-dry date is a

containing the highest flesh content. The fruits are golden yellow in colour and delicious in taste.

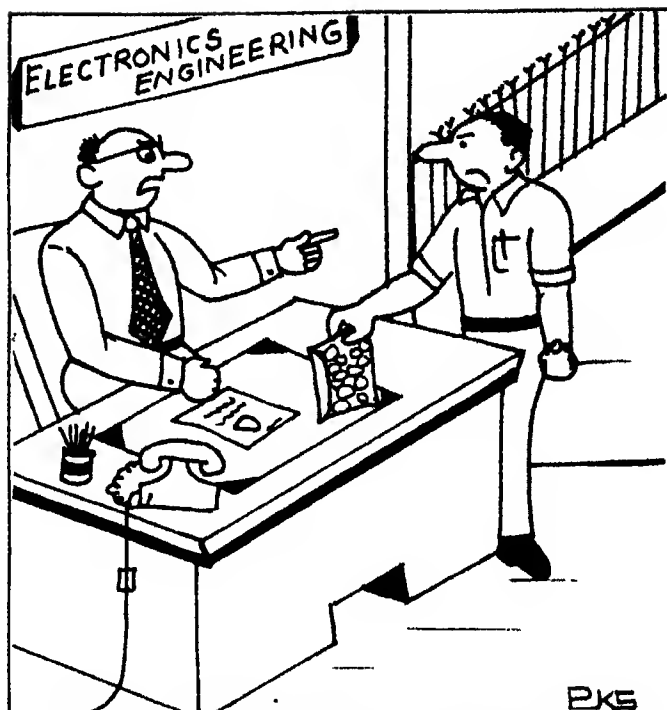
(vi) *Barhee*. It is a soft date from Iraq, Algeria and also is a leading variety. It ripens late as compared to the other varieties.

N. M. Surana
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Rajgarh-301408 (Dist. Alwar)
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IT PAYS
TO ADVERTISE IN
SCIENCE REPORTER



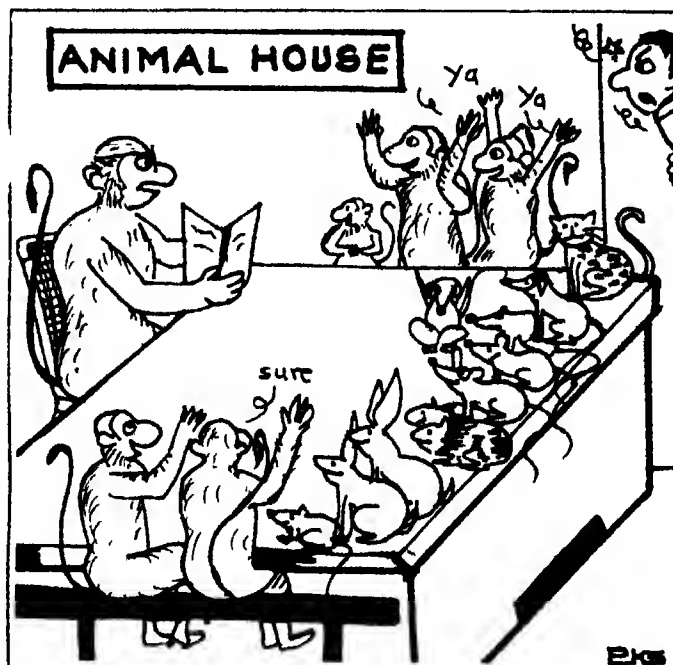
"Sir, He wants 'Japanese collaboration' to set up a bullock cart manufacturing unit"



"What is this? When I asked you to bring 'Chips', I meant 'silicon chips' and not potato chips"



"Our idea was to provide transmission facility even to the remotest part, but we never thought of this"



"May I, on behalf of all of you, apply to 'Amnesty International' for release of all of us"



FOR HER

Natural family planning methods

NATURAL family planning is the ability to plan or prevent pregnancy by utilizing the natural monthly fertility cycle in every female. Natural methods of family planning aim at identifying the fertile period as precisely as possible so that by planned sexual intercourse or abstinence at that time a pregnancy may be achieved or avoided. Attempts to enhance or diminish fertility by restricting sexual activity to given periods of the menstrual cycle are probably as old as mankind.

To adopt these methods for promoting or controlling fertility one must know about the process of ovulation and survival of spermatozoa and ova in the female reproductive tract. The fully formed and mature egg is released from the ovary on a day in the middle, that is between 14th and 16th day of the normal menstrual cycle which is mostly 28-30 days long. This egg survives for a maximum of 24 hrs in the female reproductive tract. The spermatozoa however remain alive in the female tract for a period of 48-72 hrs after intercourse.

The key to success in the natural family planning (NFP) methods, lies in the detection of ovulation. Some methods are briefly mentioned here

Calendar method

It has been indicated by various studies that menstruation takes place after 12 to 16 days of ovulation. By recording the length of cycle of a woman, the earliest day that ovulation took place can be determined by Subtracting 16 from the shortest cycle. In the same manner, the latest day that ovulation took place can be obtained by subtracting 12 from the longest cycle. Twelve is the shortest and 16 is the longest interval between ovulation and menstruation. If survival of spermatozoa and ovum is estimated at 3 days and 1 day respectively, the fertile period of a woman would start 3 days before the earliest possible ovulation and would end 1 day after the latest. Since most women tend to menstruate at regular intervals, previously recorded cycles may help in making predictions about future ones.

Mucus method

A woman can learn to detect sensations and perceive changes in cervical mucus. Immediately after menstruation, there are usually 'dry days' during which there is no perception of mucus. The fertile period begins with the 'wet days', when under the effect of circulating estrogens, cervical mucus produces a cloudy and sticky mucus discharge. This period is followed by another with more intense 'wetness'. As ovulation approaches, mucus becomes highly lubricative with the consistency of egg white. Soon after ovulation, the amount of mucus diminishes and the vaginal discharge disappears giving rise to a second 'dry' period until the following menstruation. The major advantage of the mucus method is that it has a predictive value, as coitus must be avoided whenever a 'wet day' appears. The mucus method can be used during breast-feeding or during postpartum period when normally ovulation does not take place.

Symptothermal method

This probably is the most utilized of all NFP methods. It is based on

detection of ovulation by different symptoms such as pain, mucous discharge and/or hemorrhage and by the basal body temperature (BBT). The presence of progesterone secreted by corpus luteum causes a small but detectable rise in the BBT. The rise is of about 0.2°C - 0.5°C . Sometimes, the rise is abrupt from one day to the other, at others it may last 3-4 days before reaching a hyperthermic plateau. Frequently, the rise is preceded by a dip. It is maintained while the corpus luteum is functioning. If pregnancy does not occur, the temperature drops when the corpus luteum ceases to function and menstruation begins.

Intermenstrual pain has been shown to correlate well with ovulation. Other symptoms that have been advocated are self-observation and palpation of the cervix. During the ovulatory phase, the cervix is soft and half opened; afterwards the cervix closes and its consistency hardens. Some women experience episodes of intermenstrual bleeding, frequently misinterpreted as menstruation. It has been shown that these hemorrhages coincide with ovulation.

The symptothermal method may be used by restricting coital activity to the postovulatory phase. This form has the advantage of limiting coital activity to 12 days of the cycle and it can be utilized by women with irregular cycle. The methods can be utilized with coital activity in the preovulatory phase also. The beginning of fertile period is then determined by mucous symptoms.

Out of all these NFP methods, mucus method appears to be one of the most efficient ones. In general, it appears that the symptothermal method with intercourse restricted to the postovulatory phase is the most reliable form, followed by the symptothermal method utilizing both pre and postovulatory phases. Calendar rhythm seems to be the least reliable of all the four forms.

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The enigma of Infertility

A couple is considered possibly infertile if pregnancy has not occurred within one or two years of marital relation without any contraception. According to World Health Organization, infertility is the inability to conceive within two years of unprotected intercourse. The term 'sterility' indicates complete and permanent inability to conceive even after treatment. Infertility is of two types: primary infertility or inability to have any children at all, and secondary infertility in which atleast one conception has occurred but there is inability to have additional children. Female factors account for only 50%-70% of all cases of infertility. So it is a misconception that always the females are at fault, as in 30%-50% cases the fault lies in the male partner.

Causes of female Infertility

The causes are anatomical defects in the cervix, uterus and fallopian tubes. Different types of infections,

ovulation disorders, hormonal and emotional factors and cervical mucous disorders are other causes of female infertility (Fig. 1). In many developing countries, surveys suggest that the tubal factors such as tubal infection and blockage are major causes of infertility while other causes such as ovulation disorders, endometriosis, etc., also play an important role. The major causes of tubal inflammation leading to infertility are grouped under one term 'Pelvic inflammatory disease' (PID), the major source of which are tuberculosis, postpartum and postabortal infection, sexually transmitted diseases such as gonorrhoea, chlamydia, mycoplasma, etc. Genital tuberculosis is very common in India and may be the cause of infertility in 10% cases. Schistosomiasis, a water borne parasitic disease, is also considered a cause of infertility.

Postpartum (after delivery) and postabortal (after abortion) infections are quite common causes of

PID leading to secondary infertility as the microorganisms can ascend from the dilated cervix and the tissue remaining in the uterus may promote bacterial growth. Obstetrical difficulties such as prolonged or obstructed labour, deliveries and abortions by untrained personnel, use of unsterilized instruments for delivery and abortion lead to infection causing secondary infertility. The criminal or septic abortion is another cause of infection. Apart from these causes, a few other factors such as intake of alcohol, tobacco, certain drugs as barbiturates, narcotics, anticancer drugs, etc., may be responsible. Environmental hazards as lead poisoning, radiation, pesticides, etc., may cause infertility. Malnutrition is yet another factor.

Causes of male Infertility

Males usually deny to be the cause of infertility, but they account for 30% of all causes of infertility. The woman is almost always the first of an infertile couple to be examined and usually studied more intensively than man. In many cases, man is examined only when all female factors have been excluded. Many men refuse examination as they mistakenly believe that sexual potency is a proof of fertility.

Male infertility is most often caused by one of the two conditions like blockade of the sperm ducts or disorders in sperm production. A less common condition is sexual malfunction that prevents proper ejaculation of semen. Infertile males are usually classified as 'azoospermic' (no sperm in semen) and 'oligospermic' (low sperm count in semen). Normal sperm count is 60-150 million per ml of semen but count below 20 million is called subfertility. The causes of male infertility are genital infections, tuberculosis, filariasis, leprosy, mumps, small pox and schistosomiasis (Fig.2). Hormonal, genetic and immunological factors also play a vital role in male infertility. Intake of alcohol, tobacco, drugs, radiation and pesticides hazards are other causes. Varicocele, a condition where there are dilated, tortuous testicular veins, may also be a cause of subfertility.

INFECTION

- POST-ABORTAL
- POST-PARTUM
- TUBERCULOSIS
- SEXUALLY TRANSMITTED DISEASES
- NONSEXUALLY TRANSMITTED DISEASES

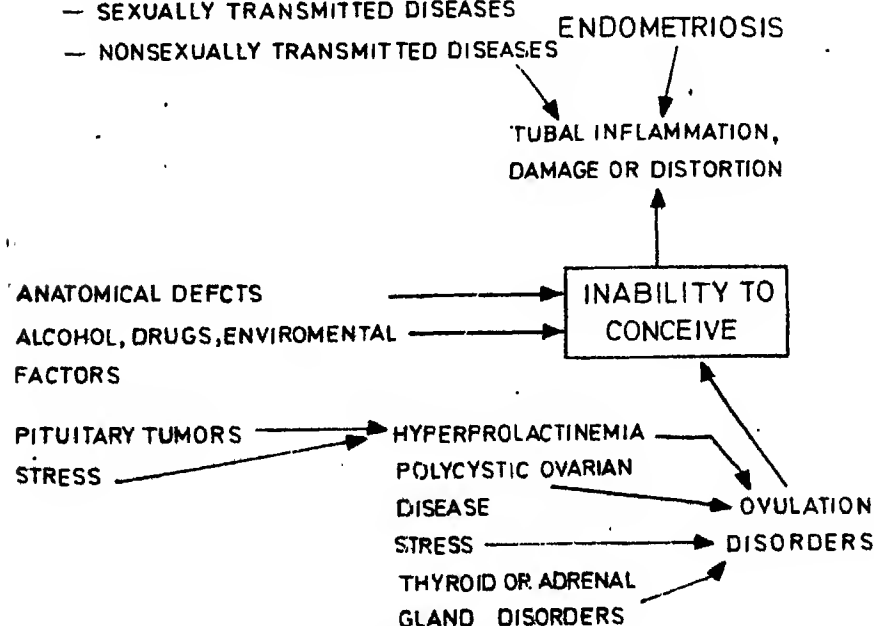


Fig.1. Causes of female Infertility

INFECTION

- TUBERCULOSIS
- SEXUALLY TRANSMITTED DISEASES
- NONSEXUALLY TRANSMITTED DISEASES
- SMALL POX

CONGENITAL DISORDERS

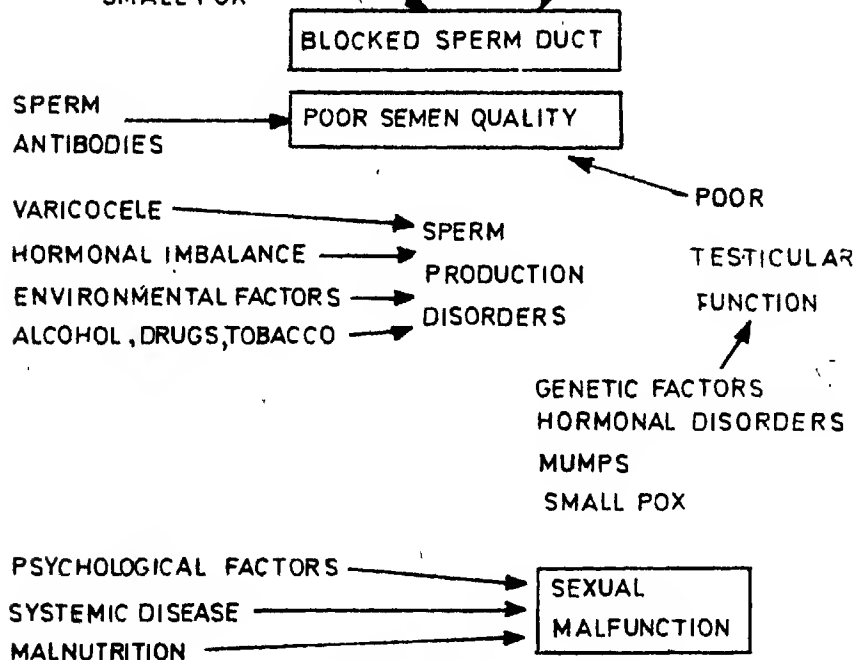


Fig.2. Causes of male infertility

Table 1. Causes of Infertility

Male	Female	Both
Low sperm count	Ovulation absent	Act of coitus abnormal
Abnormal sperms	Imperfect corpus luteum function	Sperms fail to penetrate cervical mucus
	Abnormalities congenital, post-surgery, post-infection	Sperms and ovum cannot meet because of tubal blockage functional or organic

Diagnosis

Treatment for Infertility is often unsuccessful and only 25%-50% of all couples treated achieve a live birth. The chances of success depend mostly on the causes of infertility. The simple diagnostic procedures used are; medical history and examination of both male and female, semen analysis, ovulation detection tests, tubal patency tests, laparoscopy for females and post-coital tests. The other sophisticated tests include hor-

monal assays, cytogenetic studies, immunological studies, testicular biopsy, antisperm antibodies and certain special X-rays of the skull.

History of genital infection and menstrual disorders is most important. The semen analysis should be carried out atleast 5-7 days after abstinence and the quantity, pH, liquefaction time, consistency, and microscopic examination of sperms for sperm count, motility and morphology are studied. The ovulation detection indicators are basal body

temperature charting, cervical mucus changes and endometrial biopsy. Basal body temperature rises 0.2°C-0.9°C about one or two days after ovulation indicating thereby that ovulation has occurred. The cervical mucus just after menstruation is absent or present in a small amount. Shortly before ovulation, it is sticky, cloudy and more copious. Around the time of ovulation it is plenty, slippery and clear. Endometrial biopsy is also done to assess the evidence of ovulation. The curetted material should also be sent for examination of tuberculosis.

Tubal patency can be tested by hysterosalpingography. In this technique, an X-ray of the uterus and tubes is taken after injecting some radio-opaque dye and, if the tube is patent, there will be spillage of dye in the peritoneal cavity. By this technique any anatomical defect in the uterus and tubes can also be judged. The other way to test tubal patency is to inject some gas, especially carbon dioxide, into the cervix and passage of gas through the uterus and tubes is monitored by pressure gauge. The patency test should not be performed in presence of an infection as it may spread the infection causing further harm.

Laparoscopy is a very useful technique both for diagnostic and sometimes for therapeutic purpose. In this procedure, a tube called laparoscope is passed into the abdominal cavity through a small hole in the wall of abdomen and the uterus, tubes and ovaries are visualized and any defect is noted. From the diseased area a biopsy can be taken to confirm the diagnosis. Minor therapeutic measures can be done such as cutting and cauterization of the adhesions which may be blocking the tubes.

Information about both man and woman can be obtained from another simple diagnostic test, the post-coital test. This test involves taking a sample of cervical mucus, two or three hours after intercourse near the time of ovulation. The mucus is examined under high power of microscope. A count of about 10-20 motile sperms per high power field is considered normal.

(Continued on page 127)

ENVIRONMENT

Flushing rate—an important remedy for the maintenance of Dal lake

THE Dal lake—a great tourist attraction in Kashmir—situated in backdrop of high mountains, presenting a glamorous view of nature, is under considerable strain due to encroachments and denudation of forests on its catchments. Keeping in view its importance, both in terms of aesthetic and socio-economic value, various processes pertaining to the lake system are being monitored for adoption of suitable remedial measures from time to time. One such aspect forming the text of the present communication relates to the phosphorous budget—an element of considerable and critical importance in aquatic ecosystems, delimiting growth both at micro- and macrophytic levels, determining the stage of eutrophication—in relation to the flushing rate (discharge/lake volume).

Flushing rate of water has recently been shown to be an important factor in an aquatic ecosystem having a great bearing on its mineral cycles, especially working against the phosphorus loading (input of phosphorus/lake area) and thereby serving as an important safety mechanism in its maintenance (Dillion 1974). The result of the study conducted on Dal lake (Table 1) shows the phosphorus retention co-efficient (fraction of input not lost through outflow) to decrease with increasing flushing rate and vice versa; which in simple terms would mean that with higher flushing rates more of the mineral gets flushed out of the lake system with the consequent lesser retention. The phosphorus load on the lake is evidently quite high, the chief contributors being the population residing around the lake and within it including tourists, all put together

contributing about 56% of the total income. The type is organic phosphorus mostly added in the form of human wastes—which as such are not directly useful to plants, unless rendered available through decomposition processes, and are limited however to only a few months of a solar year.

Construction of phosphorus budget in relation to flushing rate shows that though phosphorus loading is high, phosphorus concentration is not proportionately high in the lake system due to a very high flushing rate at the same time which naturally acts as an important natural in built mechanism. High flushing rate in the lake results from increased input of water into the lake due to the melting of snow in its vast mountainous catchment (area 316 km²) coupled with heavy rains especially from March to July each year.

In the lake waters, phosphorus concentration sometimes does shoot

to high levels, but the lake still does not show conditions characteristic of eutrophy as is true under similar conditions in case of other lakes in general. Various other mechanisms working hand-in-hand with flushing rate in this regard are (1) marl nature of the lake having high pH values which assist in coprecipitation of phosphorus with calcium carbonate, (2) locking up of considerable amounts of the minerals by macrophytes serving as biological sinks, and (3) dissynchronisation between availability of the mineral and growth of pattern of plants.

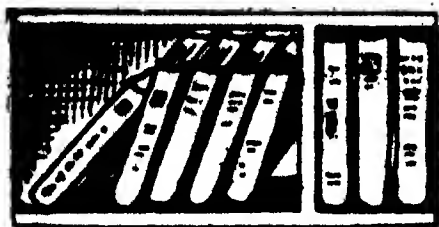
Taking a stock of overall hydrological and phosphorus flux in the lake system, the flushing rate together with built-in mechanisms as already discussed apparently plays a very important role in its maintenance, with a great scope of its further utilisation in a more profitable manner. By adjusting the time of dewatering that has lately been taken in hand with the installation of dewatering barges in the lake system keeping in view the role of macrophytes as biological sinks, as well as phosphorus input due to increased water inflow and buzzing tourist activity within and around the lake during summer, much of the mineral could be flushed out of the system in that very season. This will help in keeping the overall concentration of this key minerals

(Continued on page 127)

Table 1. Relationship of flushing rate and phosphorus loading in Dal lake (1981-1982)

Month	Flushing rate (times month ⁻¹)	P. loading (g.m ² month ⁻¹)	Retention coefficient
August 1981	1.59	0.519	0.087
September	1.18	0.463	0.493
October	0.44	0.399	0.572
November	0.18	0.379	0.805
December	0.15	0.381	0.854
January 1982	0.15	0.339	0.838
February	0.15	0.339	0.857
March	1.59	0.531	0.208
April	2.41	0.695	0.098
May	3.9	0.891	0.106
June	3.46	1.468	0.220
July	3.16	1.183	0.282

Total = 18.33 (times yr⁻¹) Total = 7.598 (g.m² yr⁻¹)



BOOK REVIEWS

THE COMPLETE GUIDE TO SUCCESS WITH THE I.B.M.P.C. JR by Vernon K. Sondak, Eileen M. Sondak and Norman E. Sondak (Available with: *B.I. Publications*, Promotion Department, 61-Lakshmi Building, Sir Phirozshah Mehta Road, Bombay-400001), Pp. 400, US. \$14.95

WHAT is I.B.M.'s P.C. Jr. all about? Well, it's a micro-computer, often called a personal computer (Junior) developed by International Business Machines Corporation, U.S.A., which incorporates the entire data processing unit on a single silicon chip. It can be useful in business for accounting, record keeping, financial management or in education for help in learning foreign languages, arithmetic, spelling or else can write letters, balance your budget, keep recipe files and can dance to the tune of your finger tips for your entertainment or amusement.

Sondak family's superb book, under review provides the necessary know-how to unveil the mysteries of the world of P.C. Jr. In this book, the authors start with the very basic concepts of computing and gradually build up the readers' confidence in computer skills as they go along its 13 chapters. Beginning with the anatomy of computers, the authors guide the readers right from taking the P.C. Jr. out of its carton and setting it up to purchasing the right software. In the next chapter, the author explains how to write and run your own program citing a few originally created programs that not only explain the fundamentals of programming but can provide hours of fun to the user. In the following few chapters, word processing, spread sheets and database management programs have been exhaustively explained.

This is followed by an introduction to BASIC and LOGO, two of the most

popular programming languages. An introduction to useful software packages, including easy writer, Visicalc, P.F.S. file and P.F.S. report are an added attraction of the book.

The book is jargon free; understandable writing style completely demystifies the P.C. Jr. A complete glossary of computer terms at the end of the book accompanied by two appendices enhance the usefulness of the book. However, the authors have not mentioned about assembly languages programs, although the processor used justifies a very powerful instruction set. Also, from time to time, they have referred the reader to go through D.O.S. and other software. They should have instead provided some useful running software.

Highly priced, the book is indispensable for success with IBM's P.C. Jr.

B.D. Prasad

EVERYDAY INDIAN PROCESSED FOODS by K.T. Achaya, *National Book Trust, India*, A-5, Green Park, New Delhi-110016, Pp. 184, Rs. 13.25

FOOD science is really an amalgam of chemistry, biochemistry and microbiology with contributions from associated subjects. There is no clear division between food science and its applied aspect, namely, food technology. The literature on food science is important in the study of basic food principles. Most of us take the food that we eat everyday for granted. It is difficult for us to find the history, chemistry, biochemistry, technology and the nutritive value of all the items—at least the commonly used foods all at one place. But the present book is an ideal source of such information presented for the lay reader in a simple and interesting manner.

The book outlines food science along with technology and nutritional quality of Indian food—both primary foods like rice, wheat, milk, vegetable oils and the processed foods like biscuits, bread, cake, chocolates, papads, pickles, vanaspati, etc. According to the author, foods described as processed run a wide gamut and even the basic staples like wheat, rice and dhal reach the market after going through mechanical processing

operations. Every chapter of this book has an interesting title.

Lalitha Vaidyanathan

WEATHER by Ian A Morrison, *Ladybird Books*, Loughborough, Leicestershire, England, Pp. 51, 70p net.

METEOROLOGY deals with atmosphere and atmospheric phenomena; study of weather and climate. The term weather is used in a more limited sense to denote the state of the sky and occurrence of precipitation or of mist or fog.

In the 17th century, countless observant people without any instruments laid the foundation of meteorology. Today it has progressed into a highly technical science. Satellites, electronic instruments, very powerful computers are used in meteorology which relay endless weather information with a minimum of delay, computers solving in minutes—at a speed beyond the capability of the human brain. Sometimes one wonders whether there is any room left for simple weather wisdom. But in fact, human experience is still the vital element which turns computed data into weather forecasts. Human observations can still provide unusual evidence which would help those who are trying to unravel the mysteries of the atmosphere.

It is generally those interested in physics and mathematics who study to become meteorologists. But the author emphasises that even those who have little interest in these subjects can become quite skilful at forecasting what the weather will do next, by using their eyes and some simple instruments.

This book is very useful for children and will help increase their powers of observation. Easy methods to forecast weather using simple instruments like thermometer, Stevenson Screen (with wet and dry thermometers), etc., observations on the study of clouds, speed of wind (Beaufort scale), snow and hailstorm, are given. A sample weather diary is given at the beginning.

Lalitha Vaidyanathan

COMPUTER AND COMPUTER CONCEPTS, *Computer Education Booklet (1)* by R. Ramaswamy (Avail-

able at 25, Chitrakala colony, Tirunagar, Madurai-625006), Pp. 18, Rs.3.00

THE booklet under review is the first of the series on computer education booklets which the author proposes to bring out in near future. In this booklet, the author has ventured to present in short all about computers. In order to use computer one must first develop two skills, namely, the problem analysis skill and the language skill. With a view to obtaining solution to a particular problem one must be able to put the problem in the form of a formula and then communicate it along with the necessary data to the computer. In computer terms, a formula is called an *algorithm*. The author briefly explains how to go about finding the algorithm for a problem. The communication of algorithms to the computer is effected through computer languages: FORTRAN, BASIC, COBOL, PL/1 and PASCAL.

Learning a computer language involves essentially learning the coding rules for variables, constants, operators and their combinations. These rules may look abstract for a beginner but with patience, logical analysis and systematic and thorough study it is not difficult to learn and master all the computer languages.

Through the booklet readers will know and learn about computers. It will certainly enable computer enthusiasts to acquire skills necessary for computer programming and the operation of computers.

P.K. Mukherjee

BIOCHEMISTRY ILLUSTRATED by Peter N. Campbell and Anthony D. Smith (Available with *B.I. Publications*, Promotion Department, 61-63 Lakshmi Building, 4th Floor, Sir Phirozshah Mehta Road, Bombay 400001), Pp 225, £ 3.75

LIVING systems display a fascinating range of chemical processes, so much so that the entire development of organic chemistry over its first hundred years or so flowed from studies of natural materials. Biochemistry is a composite

subject and for satisfactorily expounding it, one has to know both chemistry and biology; a combination often found lacking in beginners. The purpose of the book is to provide an easy access to the subject by means of concise summaries of some of the doctrines on which a more advanced study of biochemistry is based.

The authors have judiciously divided the subject into ten major areas: the first five chapters dealing with cells, proteins, nucleic acids, enzymes and coenzymes; the following three chapters cover metabolism of carbohydrates, nitrogen and fat; finally, the last two chapters deal with membrane structure and function and specialized metabolism, viz., steroids, vitamins, etc. The sequence of the topics in the book is essentially the fundamental concepts on the subject pertaining to organization, operation and interdependence of biomolecules.

The only subjective limitation of the book, as the authors have admitted, is that it is basically aimed at students interested in animal sciences, as such vital plant biochemical concepts like photosynthesis, nitrogen fixation, etc. could not be accommodated. A small chapter on practical biochemistry would be a welcome inclusion in the next edition. Despite a great many books available on this subject, the present one is a welcome addition because of its unique combination of illustrations and explicit text.

P.K. Panda

A COMPARATIVE STUDY OF COMPUTER PROGRAMS by R. Ramaswamy (Available at 25, Chitrakala Colony, Tirunagar, Madurai-625006), Pp 39, Rs 10.00

A computer may be thought of as a data converter that converts the input or raw data into meaningful data or information. The various widely used computer languages are FORTRAN, BASIC, PASCAL, PL/1 and COBOL. In order to appreciate the salient features in different languages, it is helpful to study the computer programs for the same problems written in different languages. It is with this objective that

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the booklet under review has been brought out.

Incorporated in the booklet are the programs for five typical problems, namely, payslip program, payroll schedule program, instalment payment program, depreciation accounting program and the number sorting program, written in Fortran, Basic, Pascal, PL/1 and Cobol languages. The author has taken pains to include photoblocks of computer printouts of different programs.

It is interesting to understand how the computer uses the data. Except in the Cobol program, the data in all other programs are given as part of the main program itself. In Fortran, Basic and PL/1 programs, the data are entered into the program by means of data statements. In the case of Pascal, however, since no provision exists for data statement, the data is entered through the console by means of a READ statement. The data, in the case of Cobol, are entered into the program through an external file. The Cobol language looks different from other languages. As a matter of fact, this language is more involved and complicated than other languages. Perhaps this contributes to the fact that the computing capabilities in Cobol are less than in other languages.

The study of the programs given in the booklet will undoubtedly give a lot of insight into the programming methods and styles in different computer languages.

P.K. Mukherjee

ELEMENTS OF COMPUTER PROGRAMMING by R. Ramaswamy (Available at 25, Chitrakala Colony, Tirunagar, Madurai-625006), Pp. 279, Rs. 30.00

THE book under review is an attempt to educate the beginners about the basic elements of computer programming in FORTRAN. The introductory chapter gives a brief account about functional units of a computer system, and aims at educating the readers about the various computer languages: software, hardware, etc. Chapter 2 discusses the Fortran characters and constants and the rules for

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coding these constants. Rules for coding Fortran variables and for forming Fortran expressions are included in chapter 3 which also discusses about built-in or library function. The statement which commands the computer to perform a computation is called an arithmetic statement. This is discussed in chapter 4. Input-Output statements are considered in chapter 5 while chapter 6 and 7 discuss about control statements. Type declaration statements, data statement along with a consideration of rational and logical operators appear in chapter 8. Details of flow-charting are included in chapter 9. Flowchart is, in fact, like a blue print. As an architect draws a blue print before constructing a building, so a programmer draws a flowchart before writing a program. Some flowchart illustrations are also included in this chapter.

Techniques for making the program are covered in chapter 10. Some Fortran case studies are included in chapters 11 to 14. The various subprograms including library functions, arithmetic statement functions, function subprograms and subroutine subprograms are discussed in chapters 15 and 16.

Programming by itself is a complex task indeed. Though it is not possible to eliminate the complexity altogether, attempts can, however, be made to considerably simplify this seemingly difficult task. This has led to the development of a new programming discipline called 'structured programming'. This is discussed in chapter 17. Chapter 18 is devoted to considering file operations in FORTRAN. In particular, this chapter discusses how to create program and data files and about the file activating commands.

The book is presented in a logical and systematic way. The bibliography at the end of the book will definitely serve as a ready reference for the readers. The book will no doubt be of value for the beginners in FORTRAN and for computer enthusiasts as well. Some attention must, however, be given to minimise the printing errors.

P.K. Mukherjee

PL/1 CASE STUDIES by R. Ramaswamy (Available at 25, Chitrakala Colony, Tirunagar, Madurai-625006), Pp. 77, Rs. 10.00

THE booklet under review includes photoblocks of the computer printouts of fifty PL/1 programs relating to scientific as well as business problems.

PL/1 is one of the computer languages that is widely used throughout the world, the other popularly used languages being FORTRAN, BASIC, PASCAL and COBOL. A PL/1 program essentially is made of one or more PROCEDURES. One of these is the most essential MAIN PROCEDURE. Within this are embedded the other PROCEDURES which may be present in the program proper.

The programs incorporated in the booklet under review, however, use only the MAIN PROCEDURE. The various statements in a PL/1 program are written following some set order. The program starts with the PROCEDURE statement followed by the declare statement, the processing statements and terminates finally with the END statement. All the statements in a PL/1 program must end with a semicolon. Further, it is mandatory to declare all the variables used for computation, which are generally declared as Float Binary.

The readers will certainly benefit from the programs included in the booklet. Although the programs have been run on an ORION 8000 Computer System they will be useful to other computer systems as well. Those who have learnt, or are in the process of learning, PL/1 language will also gain a lot from these programs. A good endeavour by the author indeed!

P.K. Mukherjee

FORTRAN CASE STUDIES by R. Ramaswamy (Available at 25, Chitrakala Colony, Tirunagar, Madurai-625006), Pp. 54, Rs. 10.00

AS the title itself suggests, the present book (or more aptly the booklet) discusses as to how one can go about developing algorithms and writing programs. A total of forty

Fortran programs related to scientific as well as business problems has been included in the book. Though all these programs have been run in the ORION 8000 Computer System, the basic programming is applicable to other computer systems as well. The author has taken pains to include photoblocks of the actual computer printouts. Some of the case studies concerning scientific problems include square root program, factorial program, HCF-LCM program, array reverse program, bubble sorting program, alphabetizing program, matrix addition and multiplication programs, histogram program, graph plotting program, forward difference table program, least square fitting program, Lagrangian interpolation program and the numerical integration program. Business programs covered in the book are payroll program, payroll schedule program, instalment payment program, depreciation payment program, sales report program, bank accounting program and coding and decoding programs.

The programs will certainly help beginners and computer enthusiasts to write computer programs by themselves. Those who have learnt or in the process of learning Fortran language will also be benefitted by these programs. However, some effort is needed to minimise the printing errors that have crept in the book.

P.K. Mukherjee

TELEVISION—HOW IT WORKS by RPA Edwards, Ladybird Books Loughborough, England. (Available with Penguin Overseas Ltd., 706 Eros Apartments, 56 Nehru Place, New Delhi-110019), Pp. 51, £ 0.70 (Rs. 11.40).

THE author has done a good job of explaining the steps involved from the transmission to the reception of television programmes. Anyone with knowledge of elementary science can easily get familiar with what goes on in a TV Studio and how the TV set receives the signals. The book is profusely illustrated with coloured diagrams, which not only add to the beauty of the book but

also explain lucidly the working of colour TV sets. It also explains coverage of 'out-of-the studio' broadcasts as well as the use of satellites in transmission of TV programmes all over the world. A vocabulary of important terms used is given at the end. It is certainly a good buy at this moderate price, particularly for laymen.

B.L. Arora

Books received

1. CHEMICAL AND METALLUR-

GICAL THERMODYNAMICS by Madan Lal Kapoor, (available with :Nem Chand & Bros., Civil Lines, Roorkee-247667) Pp 567, Rs. 42.50

2. WHICH MICRO & SOFTWARE REVIEW HOME COMPUTERS: THE COMPLETE BUYER'S GUIDE edited by Hazel James, (Available with : B.I. Publications Pvt. Ltd., Promotion Department, 61-63 Lakshmi Building 4th Floor, Sir Phirozshah Mehta

Road, Bombay-400001), Pp. 88, £ 4.95

3. DESIGN OF MICROPROCESSOR BASED SYSTEMS by V.K. Bansal, Wiley Eastern Limited, 4835/24 Ansari Road, Daryaganj, New Delhi-110002, Pp. 148

4. TWILIGHT AT THE WELL OF SOULS by Jackl Chaiker, Penguin books (Available with: Penguin Overseas Ltd., 706 Eros Apartment, 56 Nehru Place, New Delhi-110019), Pp. 304, Rs. 40.75

FOR HER (Continued from page 122)

Treatment

It has been observed that 30%-40% of patients conceive during the period of investigation indicating thereby a psychological factor, or some minor factor that was responsible for infertility. Otherwise, the treatment of infertility requires surgery or long-term medication. Sometimes the advice of timing coitus to coincide with ovulation may be very helpful. For an infection, antibiotics may be given to cure it. For tuberculosis anti-tubercular drugs are prescribed.

In women, clomiphene citrate may be used for ovulation disorders given orally from 5th day of menstrual cycle for 5 days in varying doses from 50 mg to 250 mg. Sometimes bromocriptine is used to induce ovulation in women with high prolactin level. Human menopausal gonadotrophin and human chorionic gonadotrophin may also be used for induction of ovulation. Surgical treatment may be carried out for blocked fallopian tubes and congenital defects in females, and on male genital organs for the blocked sperm duct and varicocele.

If the defect is in the male in form of low sperm count or defect in ejaculation, a technique called artificial insemination with husband's semen (AIH) may be tried. The aim of AIH is to assure that maximum number of sperms reach the fallopian tubes. In this technique, first part of the ejaculate, which contains maximum number of sperms, is placed at the entrance to the cervix, inside the endocervical canal or in the uterus at about the time of ovulation.

If all these measures fail and still the couple is keen to have a baby, the latest method of 'embryo transfer' commonly known as, 'test tube baby' can be suggested. In this method, in the first instance, hormonal therapy is given to stimulate ovarian activity and then to induce ripening of the ovarian follicle that releases the ova. One or more ova are recovered by laparoscopy which are incubated for about six hours before a carefully washed sperm sample is added. If fertilization occurs, the eggs are further incubated until the 2-8 cell stage is reached. They are then transferred into the uterus and hormonal therapy

is given for proper implantation. Success rate of this procedure is only about 10%. It is a very costly procedure and is still in the experimental stage.

About half of the all infertile couples will not be able to have a child of their own even after months or years of therapy. In such cases a proper counselling is advised. The couple may be advised to accept their infertility so that they do not continue to spend time and money fruitlessly seeking a cure. If the defect is in the male, then artificial insemination with a healthy donor sperm may be tried. The last resort for an infertile couple is to adopt a child within proper rules and regulations.

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ENVIRONMENT (Continued from page 123)

within limits and prevent population explosion of macrophytic species as well as the overtaking of the lake by algal blooms that otherwise are the natural results of nutrient enrichment.

Reference

Dillion, P.J., 1974, The phosphorus budget of Cameron Lake, Ontario. The importance of flushing rate to the degree of eutrophy of lakes, *Limnol. Oceanogr.*, 20(1), 28-39.

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